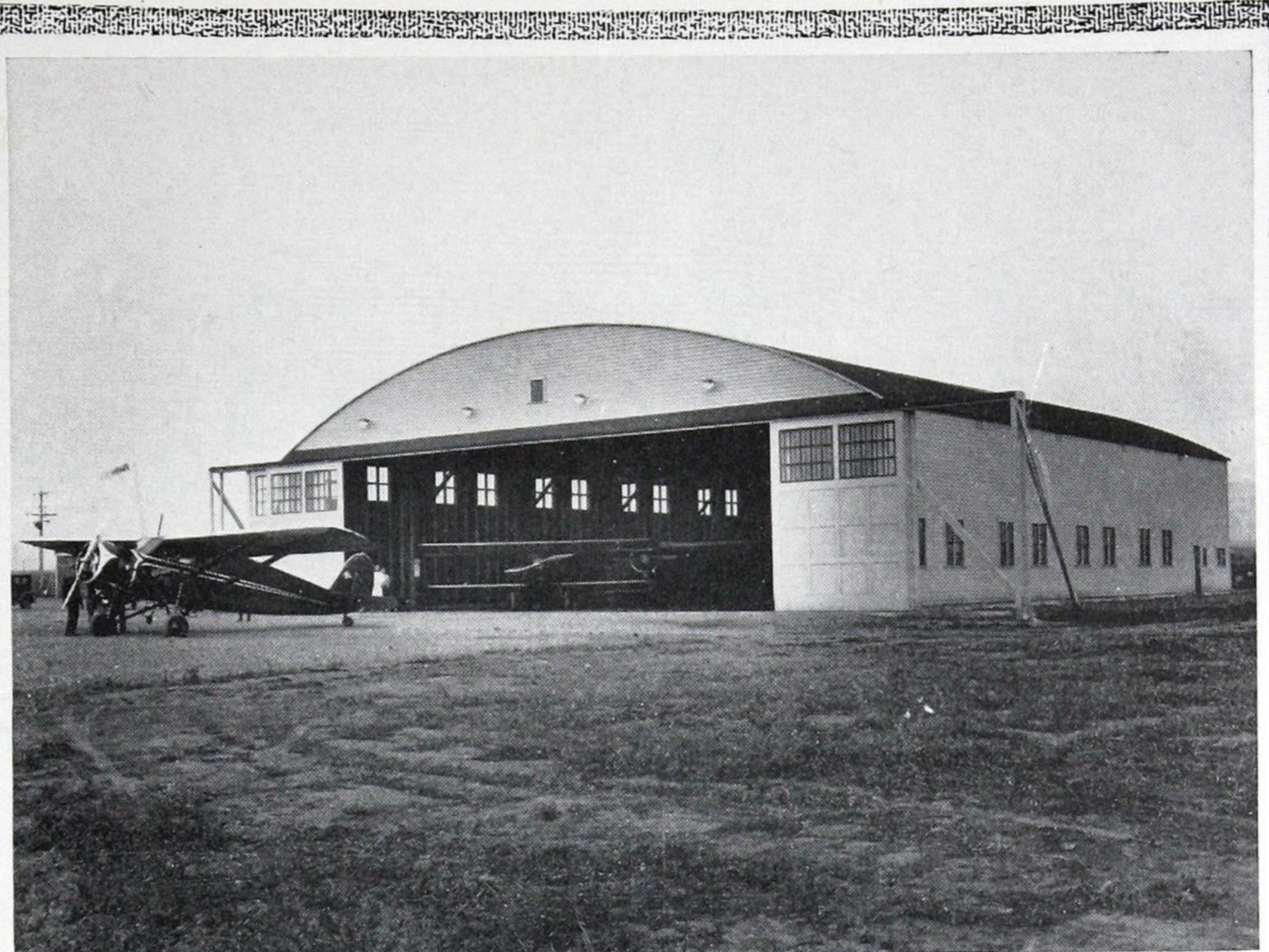
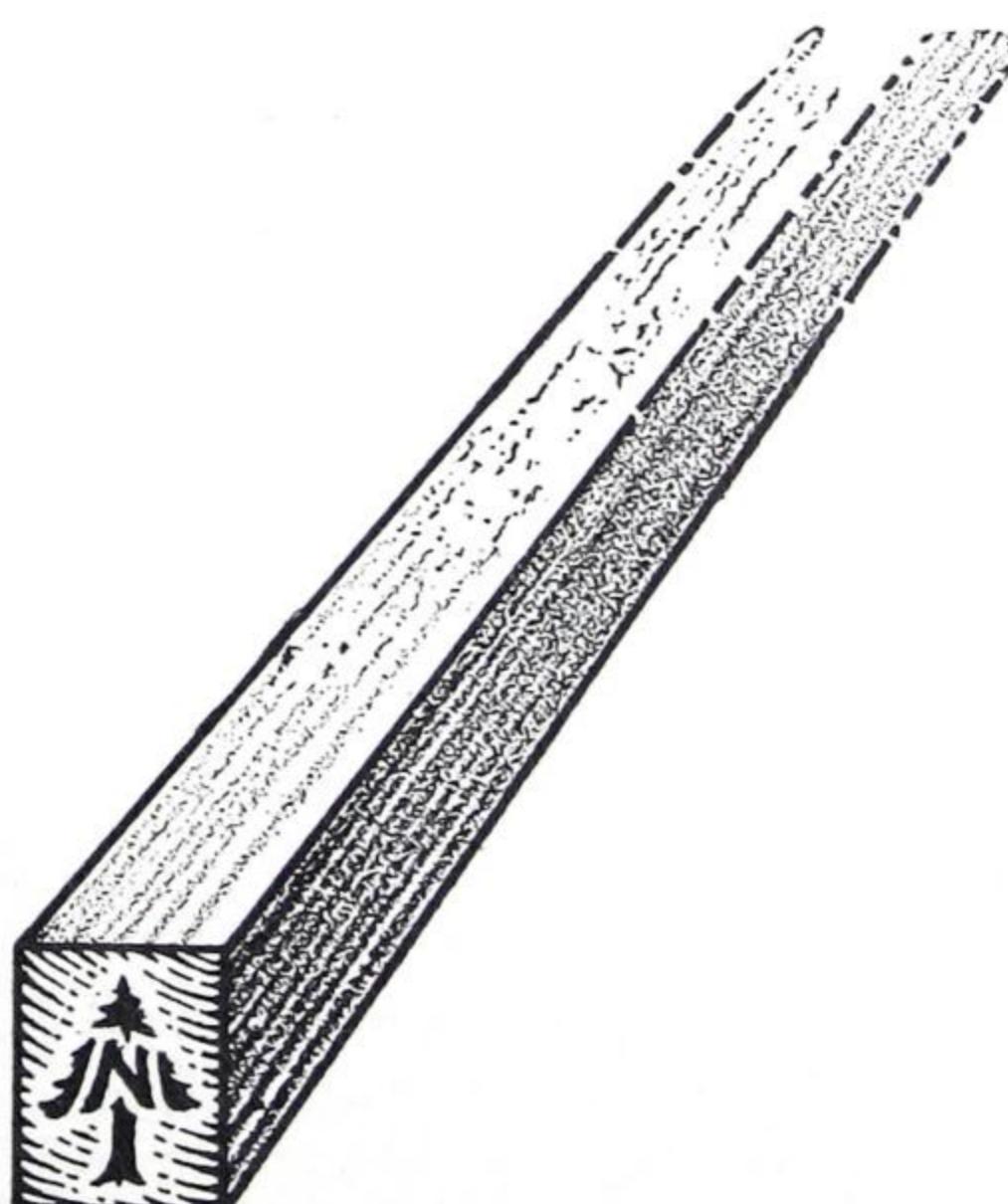


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LUMBER  
AND ITS  
UTILIZATION



# AIRPLANE HANGAR CONSTRUCTION



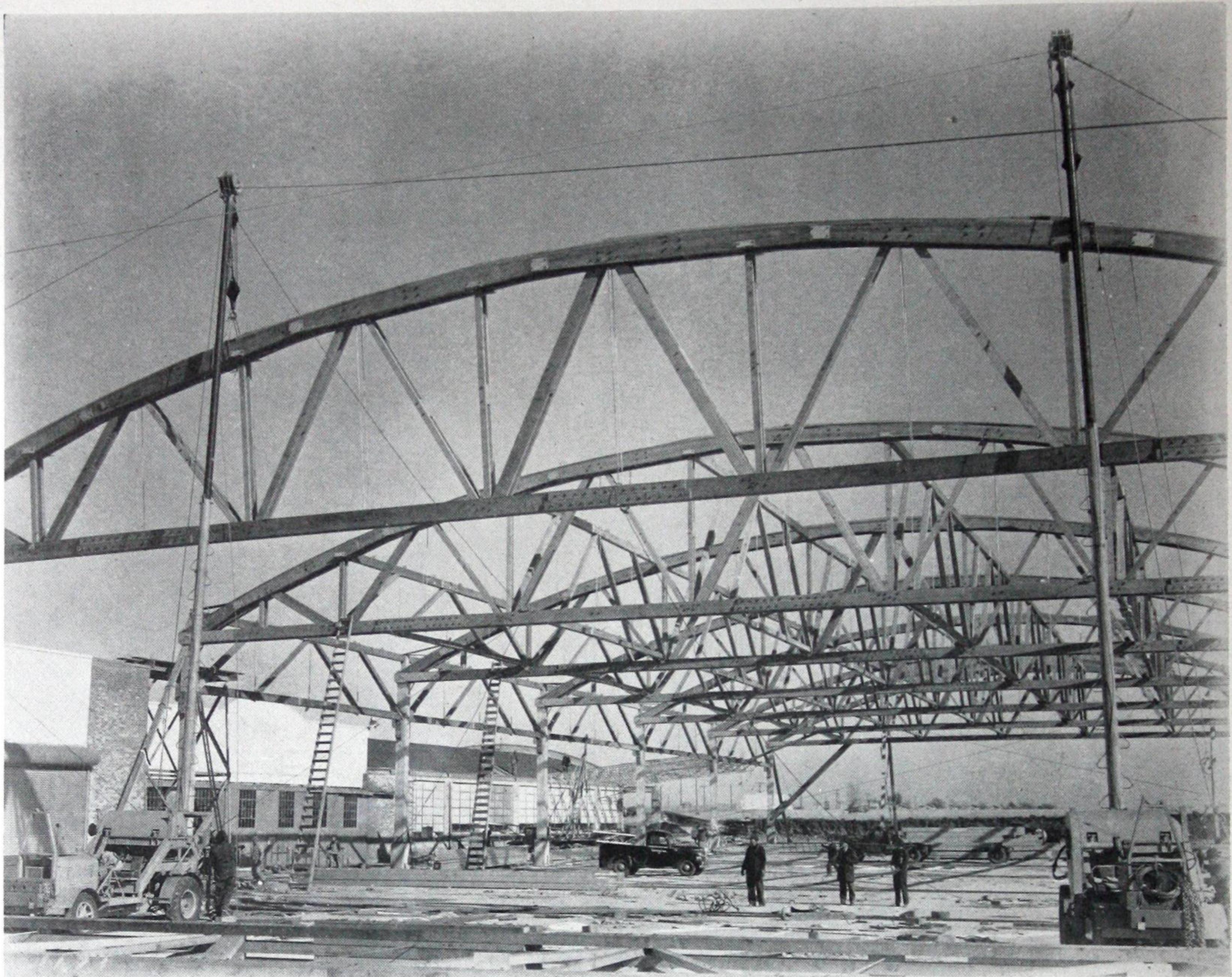
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Defense Construction for Beech Aircraft Corporation at Wichita, Kansas. Bowstring trusses during erection and in place. Span 140 ft. on 53 ft. centers. Trusses were prefabricated in Portland, Oregon, and transported by rail to Wichita.

## PREFACE

THE last edition of this publication was printed in the predepression year of 1931. Due to the reduced activity during the depression, airport and hangar work was curtailed. In these days of recovery, however, under the stimulus of National Defense and the Civil Aeronautics Authority's private pilot programs, there is an increased demand for up-to-the-minute airport and hangar information. Therefore, this edition has been prepared.

It contains information and plans to assist airport authorities, manufacturers, aviation companies, airport architects and engineers, as well as many others who may be interested in airport and hangar construction, in determining the best construction for their particular requirements.

The old information and regulations of the Bureau of Air Commerce have been replaced by the more recent recommendations of the Civil Aeronautics Authority, the agency which has

replaced the Bureau of Air Commerce. The plans in the back of the book are those developed by the C. A. A. with the co-operation of lumber industry representatives.

Complete copies of the plans mentioned above are available free of charge from the Timber Engineering Company, 1337 Connecticut Avenue, Washington, D. C. Other designs for roof trusses are available from that company and from the several commercial truss concerns.

Additional information on the properties of lumber not fully covered are available from the National Lumber Manufacturers Association. Additional information on airport and hangar construction is available from the Civil Aeronautics Authority, Bureau of Federal Airways, Technical Development Division, Airport Section, Washington, D. C., or from their regional offices.

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# AIRPLANE HANGAR CONSTRUCTION

## PART I

### THE AIRPORT—ITS IMPORTANCE

To the layman, the airport and its hangars hold little of the interest and amazement which ordinarily is attached to the airplane itself. A moment's thought, however, will soon prove the importance of this flying field, aerodrome, or whatever it may be called.

The airplane is probably one of the outstanding examples of the adage that "What goes up must come down." It naturally follows that there must be some place from which to go up and to which to return. This is the airport.

Without the airport there would be no aviation today. Aircraft exist only because the airport provides them with a place of rising into the air and descending therefrom. The airport, therefore, is not only a necessity to the conduct of aviation, but it is a part of the system.

It is likewise true that without other airports, an individual field is of little or no value as a facility to transportation. If we are to use aircraft for this, its primary and fundamental civil purpose, it is necessary that there also exist not merely a few but thousands of other similar facilities. The value of each individual airport, therefore, increases with the increase in quantity and quality of similar bases. In like manner, the value of planes and other aviation facilities is increased by greater range of use and service.

Aside from the civil benefits that may be derived, it is of interest to all people that they be protected from their present and potential enemies. The number, quality, and distribution of airports is of great importance in national defense. In the United States there are many Army and Navy fields. These fields were constructed for peacetime usage and even under such conditions have been severely overcrowded. In times of emergency, our military and naval air forces must of necessity depend upon civil airports as bases of operation. The efficiency and power of these air services is directly in proportion to the facilities, of which airports are a major item, which are available for use.

### THE HISTORY OF THE AIRPORT

Before the present and the future of the airport are considered, it is well that the past should be studied.

Aviation was of little importance either civil or military prior to 1910. Its first progress took place during World War I, with rapid development taking place in the twenties, a slight lull through the early depression days, and with feverish activity from 1933 to the present. The airport has had much the same degree of development but with usually a lag due to the ever existent inability of man to foresee and predict the future.

In the early days following 1910 an airport as such was either a rarity or nonexistent. Exhibitionists or barnstormers were the first publicists of aviation. These enthusiasts were satisfied with nearly any relatively flat and open field (oftentimes the enclosure within a race-track), because they had to be. Planes and pilots were few and a curiosity at this time when "die-hards" were still advising motorists to "get a horse." In 1912 at the time of the first transcontinental flight, there were only 20 fields which had been used with sufficient frequency to become known as landing fields.

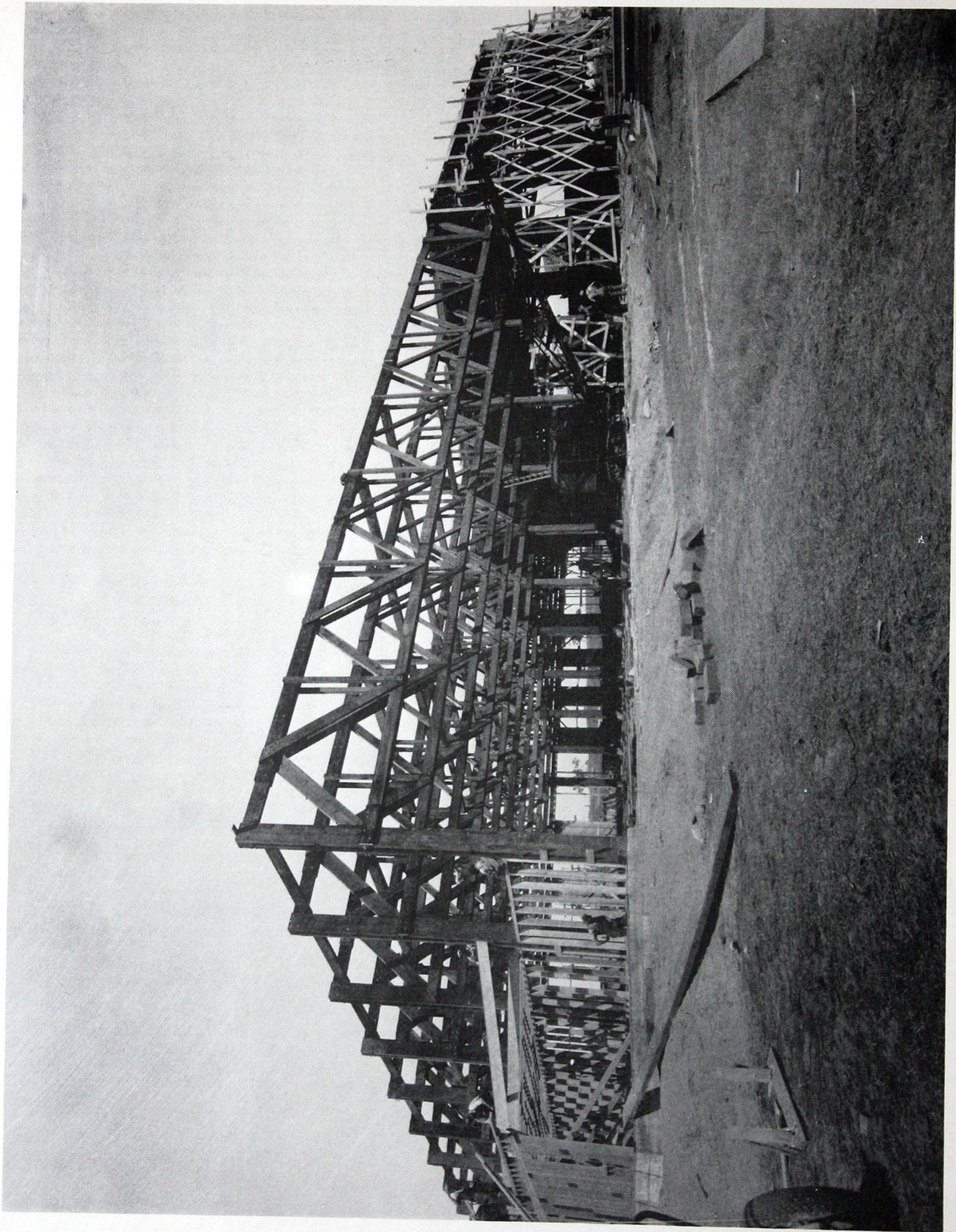
The Aero Club of America in 1915 first promulgated the idea of a string of fields to be used for cross-country travel. The use of airplanes for the first time as military weapons of attack and observation in the then existent European conflict provided further stimulus to the enthusiasts in this country. With our entry into the war, American aviation from the military side grew, literally, over night. During our eighteen months of activity, airplanes in huge quantities were produced and our number of pilots grew from a handful to over 15,000.

This interest aroused by the war left the country with thousands who knew and loved aviation. The idea of strings of airports prior to the war grew into the plans of a system of airways after the war.

The Army, impressed by the part aviation had played in the war, assisted in and promoted the development of civil landing fields. They established several fields for use in cross-country practise hops and many of these were later taken over and maintained by civil or private authorities.

The Post Office Department inaugurated the air mail service with the first mail being flown from Long Island to Washington on May 15, 1918.

The combined efforts of the Post Office Department,



View of 112 ft. clear span lean-to shop and falsework during erection of double hangar under Canadian Air Defense Program.

the Army and the many barnstormers soon had the development of aviation moving rapidly. Their efforts resulted in the establishment, by the beginning of 1921, of 271 airports, of which 145 were municipal. Many of these airport sites, however, had been chosen unwisely and this led to some discouragements in the following few years. The need for lighted airways to facilitate night flying and the desirability of intermediate emergency fields became apparent. The Federal Government established the first of these facilities in 1924.

The number of airports had increased to about 700 in 1925. In 1926 the Air Commerce Act was passed. This act created an agency empowered with regulatory powers over the airways. Although the act specifically prohibited this agency from establishing, operating, or maintaining airports, the total number of airports, possibly as a result of encouraging governmental supervision of the airways and the awarding of mail contracts to private concerns to aid them in the establishment of scheduled air transportation, rose to about 900 in 1927.

Further encouragement and realization of possibilities were stimulated in 1927 as a result of cross-country and transoceanic flights. The Lone Eagle's classic flight aroused the imagination of the populace and caused the private operators to plunge into a boom period that lasted through 1929.

As the flow of capital lessened, gradually although not as rapidly as in other fields, the airport development

program gradually receded until it was practically at a standstill in 1933.

Like all other construction work, from 1933 to date the influx of government capital revived the program and through the various governmental works agencies many new airports were developed and many existent fields were improved. During the latter part of this period private capital has begun to be used more freely again and military aviation once again has reached a position of prime importance. These two factors have likewise contributed greatly to further development of the airport.

In 1938 there were a total of over 2,250 airports existent in the United States. Unfortunately, however, these airports are not well distributed geographically. Too, a very large number of these are not much more than fields which could be used only in emergency. In many locations there is a great need for improved airports and, even more important, in some sections no airports of any description exist.

Figure I on the next page graphically presents the airport situation as it now exists. In some cases, it will be noted from the map, some points are more than 100 miles from an airport of any description. Many of these points, too, are not in rugged country where construction of fields is difficult or impossible but in the prairie states where fields are a natural feature.

To further explain the need for more and better air-

TABLE NO. 1

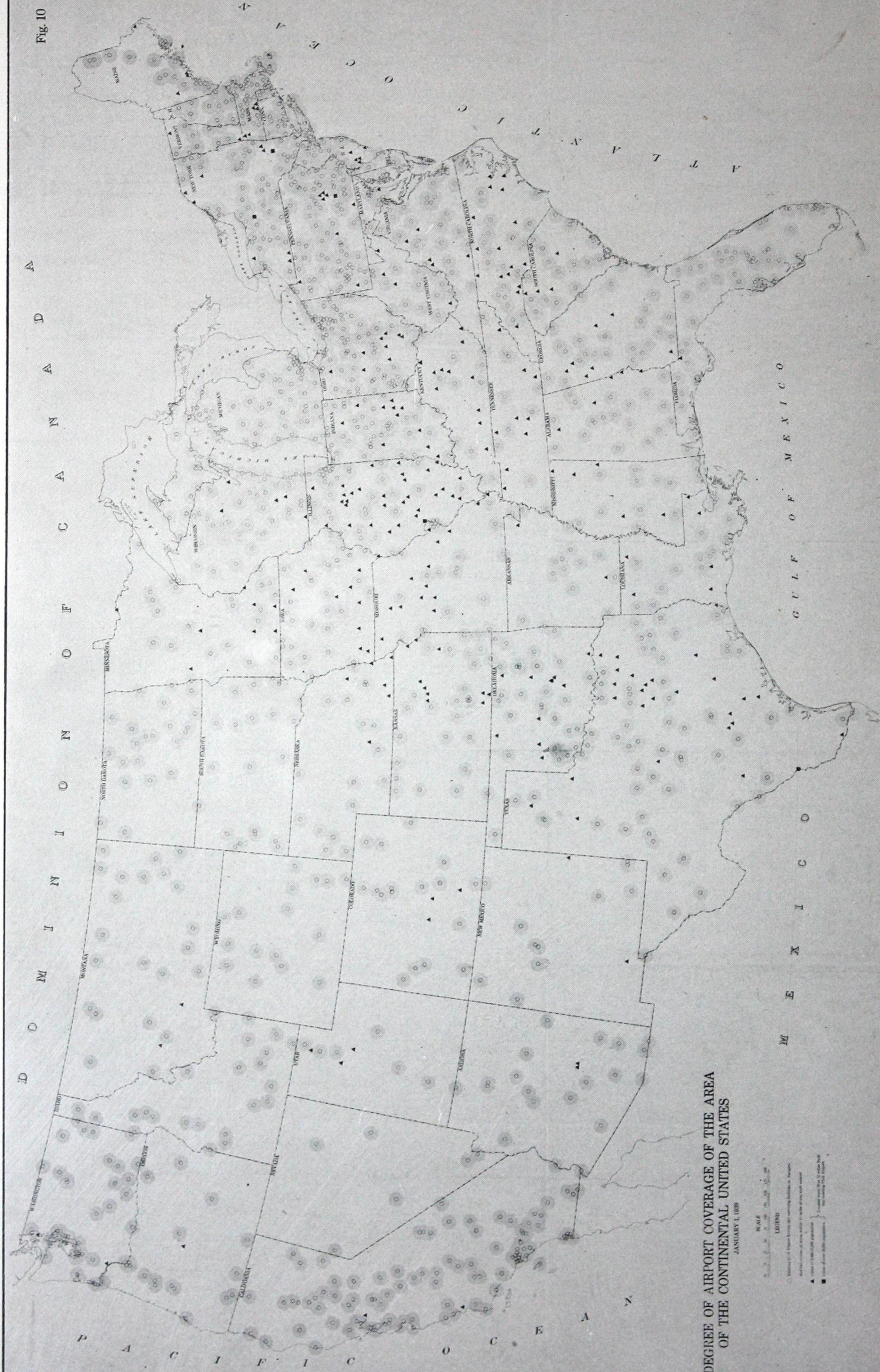
## RECOMMENDED AIRPORT DESIGN STANDARDS FOR COMMUNITIES, CITIES AND METROPOLITAN AREAS

Type of Community	Planning Classification	Recommended Landing Strip Lengths—Sea Level Conditions—Clear Approaches*	Type of Aircraft Which Airport May Safely Accommodate
Small communities not on present or proposed scheduled air carrier system. Includes communities up to a population of approximately 5,000.	1	1,800' to 2,500'	Small private owner type planes. This includes roughly planes up to a gross weight of 4,000 pounds, or having a wing loading (lbs./sq. ft.) times power loading (lbs./HP) not exceeding 190.
Larger communities located on present or proposed feeder line airways and which have considerable aeronautical activity. General population range 5,000 to 25,000.	2	2,500' to 3,500'	Larger size private owner type planes and some small size transport planes. This represents roughly planes in the gross weight classification between 4,000 and 15,000 pounds, or having a wing loading (lbs./sq. ft.) times power loadings (lbs./HP) of 190 to 230.
Important cities on feeder line airway systems and many intermediate points on the main line airways. General population range 25,000 to several hundred thousand.	3	3,500' to 4,500'	Present day transport planes. Planes in this classification are represented approximately by those between 10,000 and 50,000 pounds gross weight, or by those having a wing loading (lbs./sq. ft.) times power loading (lbs./HP) of 230 and over.
Cities in this group represent the major industrial centers of the nation and important junction points or terminals on the airways system.	4	4,500' and over	Largest planes in use and those planned for the immediate future. This approximately represents planes having a gross weight of 50,000 pounds and over or having a wing loading (lbs./sq. ft.) times power loading (lbs./HP) of 230 and over.

\* Approaches shall be clear within a glide path of 20 to 1 from the ends of the runways in the case of Class 1 airports and 30 to 1 in the case of Class 2, 3, and 4 airports except for instrument landing runways for which the ratio shall be 40 to 1 from a point 4,500 feet from the beginning of the runway.

NOTE.—For scheduled operations of small transport planes 3,000' is the minimum length recommended at present. For other scheduled operations 3,500' should be the minimum considered.

Fig. 10



ports, a survey conducted in the late thirties by the Civil Aeronautics Authority shows less than one-fifteenth of the total number are properly equipped. Another one-fifteenth have all requirements except the proper runways. About one-third have only hangars and fueling facilities but, due to lack of lights, can be used only during the day. The survey also gives the following surprising statement. "A TRIFLE MORE THAN ONE-HALF OF ALL THE EXISTING CIVIL AIRPORTS LACK EITHER A HANGAR OR FUELING FACILITIES; AND SUCH FIELDS CAN BE CONSIDERED AS AIRPORTS ONLY BY COURTESY, AND IN DEFAULT OF ANY BASE WITH EVEN AN APPROXIMATION TO PROPER EQUIPMENT IN THE NEIGHBORHOOD."

This brief résumé serves to show two things and they are, first: that more airports are needed; and, second: that existing airports need improvements and facilities. In order to better understand what these needed facilities are it may be well to consider the various standards set up by the C. A. A. for different classes of airports.

Table I gives the recommended airport design standards for communities, cities and metropolitan areas as set up by the Airport Section of the Technical Development Division of the Civil Aeronautics Authority.

Table II below gives the airport size planning standards of the same group. It will be noted that for all classifications other than the minimum that hangars are required. This, however, does not mean that the Class 1 field should not have plane housing facilities. In fact it is advisable to provide storage and repair facilities wherever planes spend any considerable time unused. This protection means longer life for the planes in which considerable sums of money have been invested. Repair and inspection shops for adequate care of the planes preclude the possibility of mechanical failures.

### Selection of Site

In selecting any airport site, there are several factors which must be considered. These include, primarily, safety of operations, then possible expansion, freedom from obstructions, location as to other airports, meteorological conditions, accessibility, topography, soil characteristics, availability of construction materials, location with respect to utilities, and many economic considerations.

After the site is selected there are many construction jobs necessary. The field must be graded, drainage facilities must be designed and built, runways must be located, designed, and prepared, and finally buildings must be designed and erected.

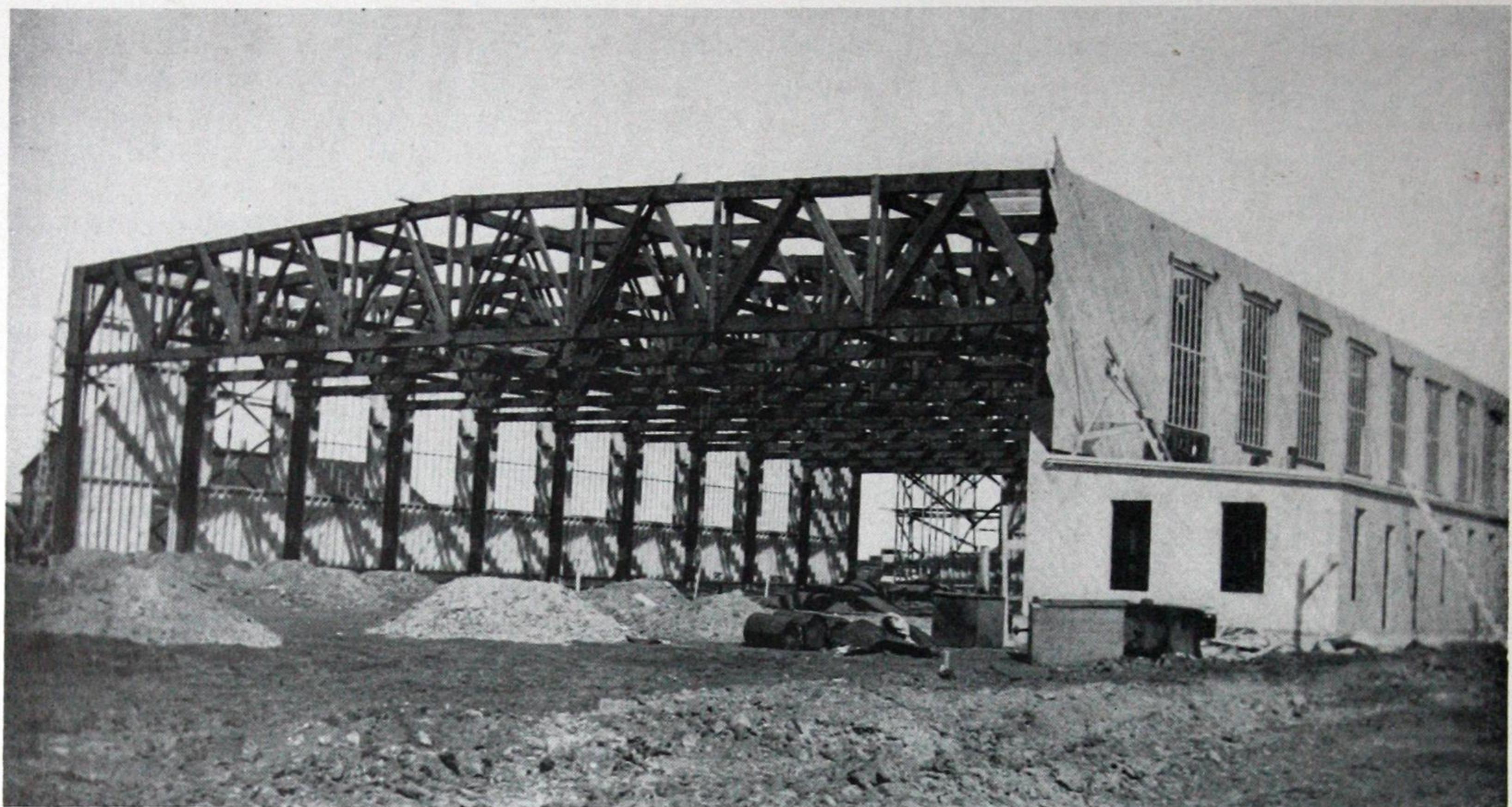
TABLE NO. 2  
AIRPORT SIZE PLANNING STANDARDS

RECOMMENDED MINIMUM STANDARDS	CLASS 1	CLASS 2	CLASS 3	CLASS 4
* Length of Landing Strips	1800' to 2500'	2500' to 3500'	3500' to 4500'	4500' and over
Width of usable landing strips	300'	500'	500'	500'
Length of runways	None	2500' to 3500'	3500' to 4500'	4500' and over
Width of runways	None	150' (Night Oper.) 100' (Day oper. only)	200' (Instrument) 150' (Night oper.) 100' (Day oper. only)	200' (Instrument) 150' (Night oper.) 100' (Day oper. only)
** Number of landing strips & runways determined by percentage of winds, including calms***, covered by landing strip & runway alignment.	75%	80%	90%	90%
Facilities	Drainage Fencing Marking Wind direction indicator	Drainage Fencing Marking Wind direction indicator Lighting Hangar & Shop Fueling Weather Bureau Weather Information Office Space	Drainage Fencing Marking Wind direction indicator Lighting Hangar & Shop Fueling Weather Bureau Two-way radio Visual traffic control Instrument approach system—when required	Drainage Fencing Marking Wind direction indicator Lighting Hangar & Shop Fueling Weather Bureau Two-way radio Visual traffic control Instrument approach system—when required Same as for Class 3 (Administration Bldg.)

\* All of the above landing strip and runway lengths are based on sea level conditions; for higher altitudes increases are necessary. One surfaced runway is recommended for the effective length of each landing strip for airports in Classes 2, 3, & 4.

\*\* Landing strips and runways should be sufficient in number to permit take-offs and landings to be made within  $22\frac{1}{2}^\circ$  of the true wind direction for the percentage shown above of winds 4 miles per hour and over, based on at least a 10 year Weather Bureau wind record where possible.

\*\*\* Calms: Negligible wind conditions of 3 miles per hour and under.



Typical hangar, as built by the Canadian Government for their air training program, under construction. Warren type trusses of 112 ft. span provide a 20 ft. door height for land planes and a 26 ft. height for sea planes. Note the use of diagonal wood sheathing for increased rigidity.

## AIRPORT BUILDINGS

This publication deals chiefly with the buildings needed at airports. There are two fundamental types of such buildings. First and most necessary, is the hangar which offers shelter to the planes, and second, is the administration building which houses facilities for operation of the airport with reference to the pay load. Either of these buildings may vary all the way from small one-plane or one-room buildings to huge, spacious and expensive structures.

### Operations Buildings

Administration buildings in general are not unusual in their design. In general they follow the principles of terminal buildings as used by bus companies and railroads for some time. They provide facilities for ticket handling, handling of passengers, and as the size and importance grows, post office space, freight space, administration space, provision for the U. S. Weather Bureau, an airways communications office, airway traffic control room, and the airway traffic control tower.

### Hangars

The hangar, however, is somewhat different from most structures. It is an unusual building primarily because

it must provide huge door openings. These hangars may be used to house a single small sport plane or they may have to be large enough to house our large transports or bombers.

### Hangar Requirements

While no specific regulations are laid down for hangar details by the C. A. A., they do recommend certain minimum door clearances as shown in this table:

Span	Door Height
40'	12'
60'	16'
80'	18'
100'	22'
120'	22' to 28'
160'	28' to 36'
180'	36' and over

### Size

The proper size for a hangar will depend chiefly on the dimensions of the various planes which the airport authorities may decide to house. Several factors will ordinarily enter into such a decision.

The larger cities of the country will naturally desire large airports and hangars, chiefly because the largest planes will naturally travel via the large cities.

For the moderately sized city and the smaller communities, the decision is not so obvious. Is the city on an established or potential mail route? Is it on the normal path of intercity air-travel? If so, even though it is a small town, it will receive a certain proportion of visits from large planes, provided the landing field is suitable and the hangars and other facilities are adequate. Satisfactory airports will be marked and will be known by all pilots flying over them, and so, if thickening weather or other trouble necessitates a landing along the route, the airport with known accommodations will be the one selected.

On the other hand, a much larger town or city, off the regular flying routes, would have less need for housing for large, passenger-carrying planes. Such a city might, however, be a center of attraction for the small types of planes, adapted to commercial uses where a pilot and one or two passengers would be the maximum load.

For the ordinary medium sized city or town, not on a natural flying route between larger cities, a moderate sized hangar will suffice, but even here future possibilities of expansion should be considered. If the landing field is large enough to meet all future demands, the hangars and other buildings can easily be added to or changed from time to time as conditions may demand and funds permit. This is particularly true if the port buildings are of lumber construction.

Recent developments in airplane construction indicate clearly the need of larger hangars, higher door clearances and wider, unbroken floor spaces. Many expensive hangars built only three or four years ago are now usable only by small ships. This again emphasizes the wisdom of using for hangar construction a low cost material in which alterations are easily made.

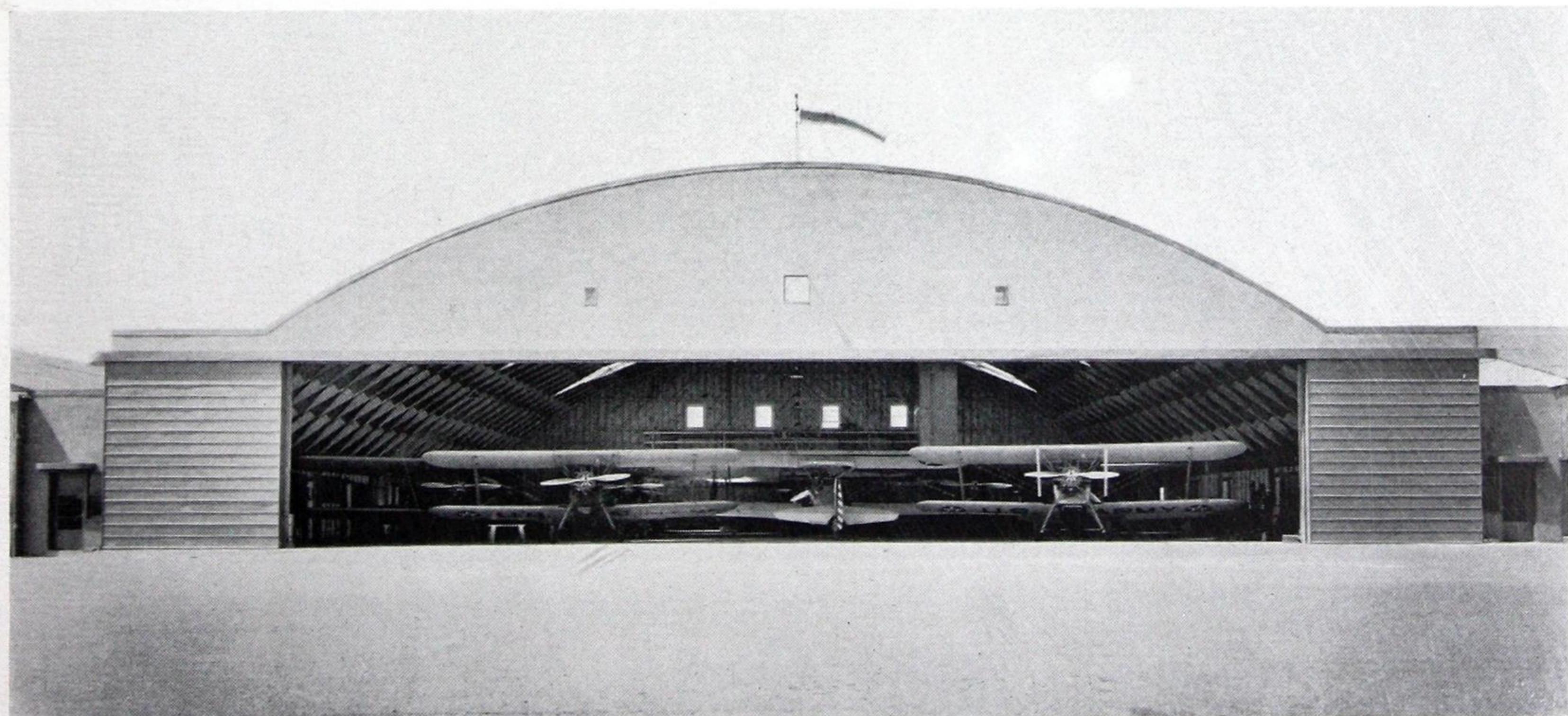
Plans and other details for hangars to meet any requirement are shown at the end of this bulletin.

### Location of Buildings

Vitally linked up with the determination of the hangar size, is its proper location on the landing field, as well as the selection of the most suitable material to use in its construction.

The hangars and other airport buildings, such as fuel shed, quarters for personnel, waiting room, repair shop and fire-equipment shed, should be placed at that side of the field where they will interfere least with plane operation. It is better still to erect the buildings on a section of the field which cannot now or in the future be utilized for landing.

Consideration should be given to surface transportation, including a good road, leading from the airport and its buildings out to the nearest highway, without crossing the landing field. It is well to keep in mind that the door openings of hangars should not be in line with the direction either of the prevailing winds or of the runway strip used in landing and taking off. Other-



U. S. Army Hangar at Santa Maria School of Aeronautics, California. Lamella roof system with bowstring truss across door opening. Clear span of 115 feet.



112 ft. Warren trusses during erection with double gin pole for Canadian Air Training Program hangar.

wise, dust, cinders, and debris will be continually blowing into the hangars.

Another point to consider is that planes can take off and land with greater ease and safety, when they are flying directly against the wind. Consequently, if a hangar or other building is directly in line with the wind and the landing strip, a plane in landing must clear such building, with the result that the available landing space is materially reduced.

The character of the terrain also will influence the location of the hangar. Uneven ground may require considerable grading to permit the construction of concrete or cinder floors inside of the hangar. In several cases which have been reported, this expensive grading has been avoided by raising the hangar slightly above the level of the field, by means of wood posts and girders, to support the floor and structure.

Wood floors should be of two-inch matched plank, supported at suitable intervals by girders or floor beams. They should not be in direct contact with the soil, and ample opportunity for ventilation below the floor should be provided. Wood floors are more comfortable than concrete or cinders for mechanics to stand or work on, and in most cases are more economical.

#### Paved Areas

As an aid to the ground force in wheeling airplanes to and from the hangar and for the general appearance and cleanliness of the field, many of the larger airports have connected the hangars with the landing strips and other buildings by means of concrete aprons or other prepared surfaces of cinders or gravel. These paved areas are necessary at landing fields which are frequently soft or muddy, or where trucks and other vehicles are used.

#### CHOICE OF BUILDING CONSTRUCTION

The auspices under which airports have been developed vary widely, and hangars so far constructed have varied all the way from cheap makeshifts of sheet metal and thin steel shapes to elaborate and expensive buildings with heavy structural steel frames and masonry walls. Lumber hangars, for many reasons, have made up a great proportion of the total.

Airplane hangars should be economical in first cost and maintenance, durable, easy to erect, demolish or remodel, economical to heat and easy to maintain at comfortable working temperatures. So far as is consistent with reasonable economy, and the necessary requirements of use, the hangar should be resistive to fire and high wind pressures. Except for one or two types, service

requirements can be met satisfactorily by practically any of the types of construction now in use, providing sufficient funds can be spared for the purpose.

#### Savings in First Cost and in Annual Charges

The lumber-built hangar is admittedly the most economical efficient type of building for housing airplanes. Its first cost, as evidenced in a number of cases, is from 15 per cent to 60 per cent lower than that of hangars of equal quality built of other materials.

Timber trusses for typical airplane hangar spans are considerably less expensive than those of steel. Steel trusses will usually cost from 10% to 100% more than timber trusses, depending on local conditions. Quotations on timber trusses vary with the locality.

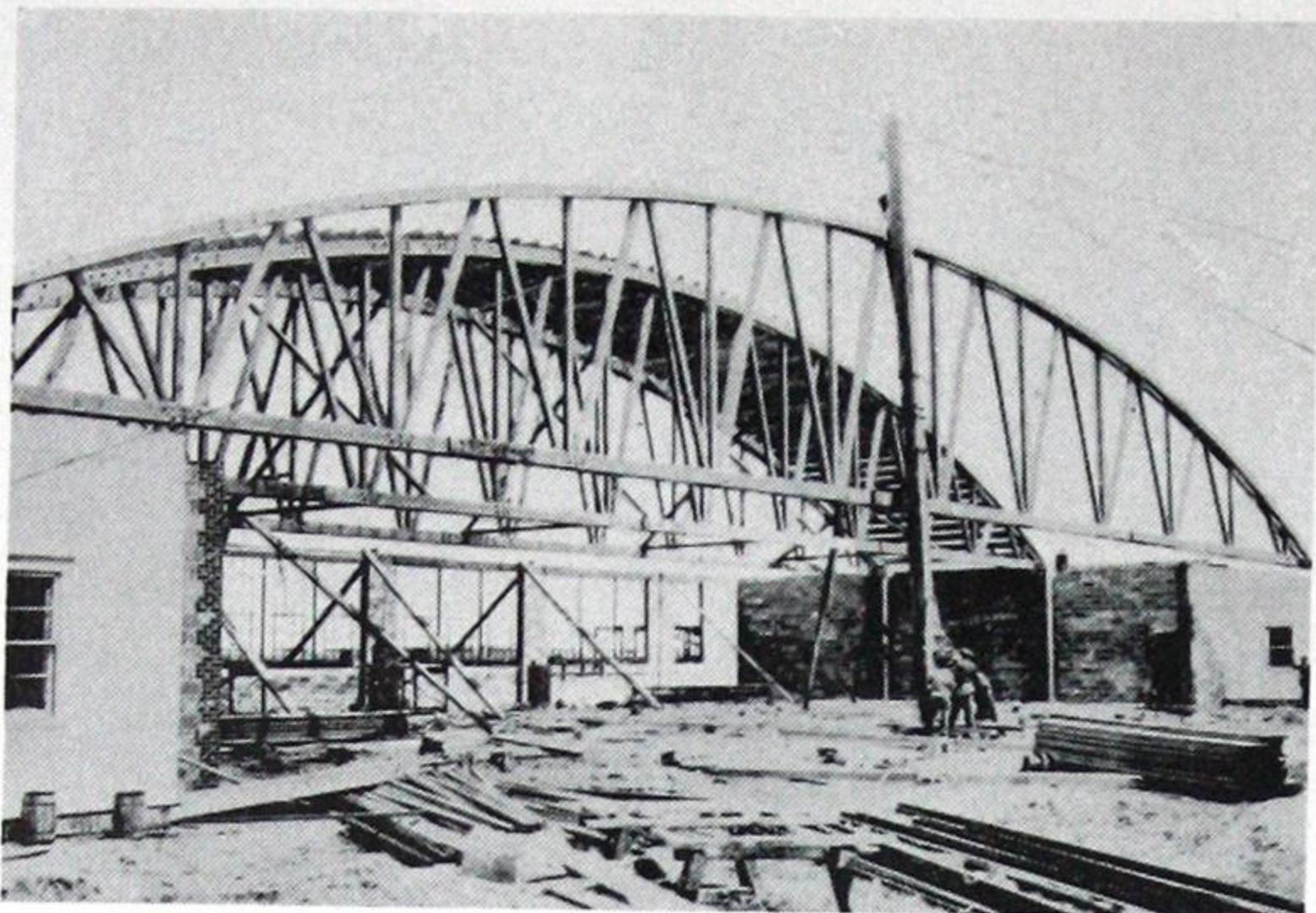
Comparative prices offered to the Air Corps of the U. S. Army in 1940 for a 120' x 200' hangar showed the competitive material to cost approximately 25% more than timber.

In addition to the lower first cost of lumber hangars there is a pronounced reduction in annual carrying charges and cost of maintenance, which should not be overlooked. Where \$1,000 is saved on the first cost of a small hangar, an additional amount representing the interest on \$1,000 also is saved every year. Where hangars are privately owned, taxes also are saved on the difference between the two valuations. In instances where a higher insurance rate is imposed on lumber hangars, it will often be found that the lower assessment of the lumber structure will more than offset difference in premiums.

#### Proper Care Important

Exterior of lumber buildings are usually painted for appearance and to prevent weathering of the surface. Sheet iron must be painted on both inside and outside if rust due to interior condensation is to be avoided. All windows and trim, no matter what materials are used for side walls, also require painting. The cost of painting hangars is greatly decreased by use of paint spraying equipment, which gives excellent results and can be applied efficiently to the large unbroken areas involved.

Structural depreciation and obsolescence, due to loss of utility, are two essentially different factors, which compete for the privilege of writing "finish" to many a building episode. In the majority of cases, obsolescence wins out and modern business and industrial structures lose their utility long before they must be abandoned for structural reasons. This is true of growing and developing enterprises and may be expected to be particularly true of airplane hangars. With one



**AIRPLANE HANGAR, WILMINGTON, DELAWARE.** 150' bowstring trusses by Roof Structures, Inc., New York City. The top chords are glued to solid curved pieces. Chords are 2-6" x 12", web members are 6" x 6". TECO split ring connectors used at connections.

or two exceptions, almost any type of construction will insure a longer structural life than will probably be needed, and a large proportion of hangars now in use presumably will be removed, remodeled, or torn down before they are structurally unsafe or unserviceable.

Lumber buildings such as illustrated in the following pages of this publication have been in use for many purposes over long terms of years, as warehouses, sheds for building material, factories, garages, barns, and cotton compresses. Often with an absolute minimum of painting or other maintenance, large numbers of such buildings have demonstrated their structural serviceability for long periods. Reasonably protected from accumulations of moisture, lumber will not rot. Unless equally protected, steel, its principal competitor in this field, fails through rust.

Careful painting will prolong the life of any type considerably but there is little question that on the basis of durability, the use of lumber for hangars is emphatically justifiable.

#### Adaptability to Reconstruction

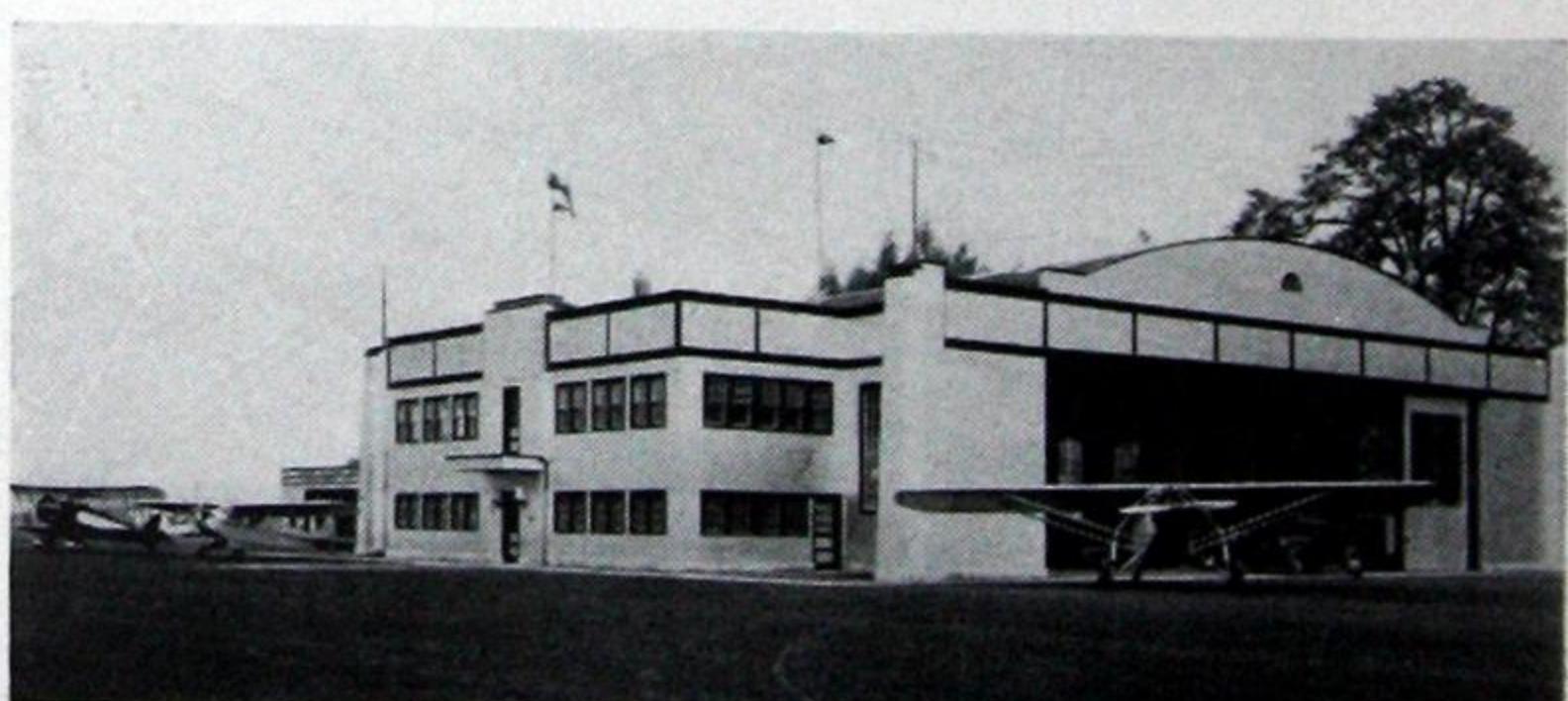
In view of the further consideration that hangars now in use, or built in the near future, will in many instances require to be removed or extensively remodeled to meet unforeseen demands, the advantages of lumber in this respect are well worth consideration. Lumber buildings are light, sufficiently flexible to withstand the effects of moving, and readily remodeled or adapted to new purposes. No imported skilled artisans are required when building with lumber. Every community has its carpenters who are familiar with lumber and who know

how to use it. Lumber is available everywhere on short notice in classified grades of definite quality and in accurate sizes. It can be purchased locally and labor can be secured locally. The buildings can be quickly and easily erected, the money for their erection stays in the city and local labor is benefited instead of traveling erection gangs, which are in one city this week and in another the next.

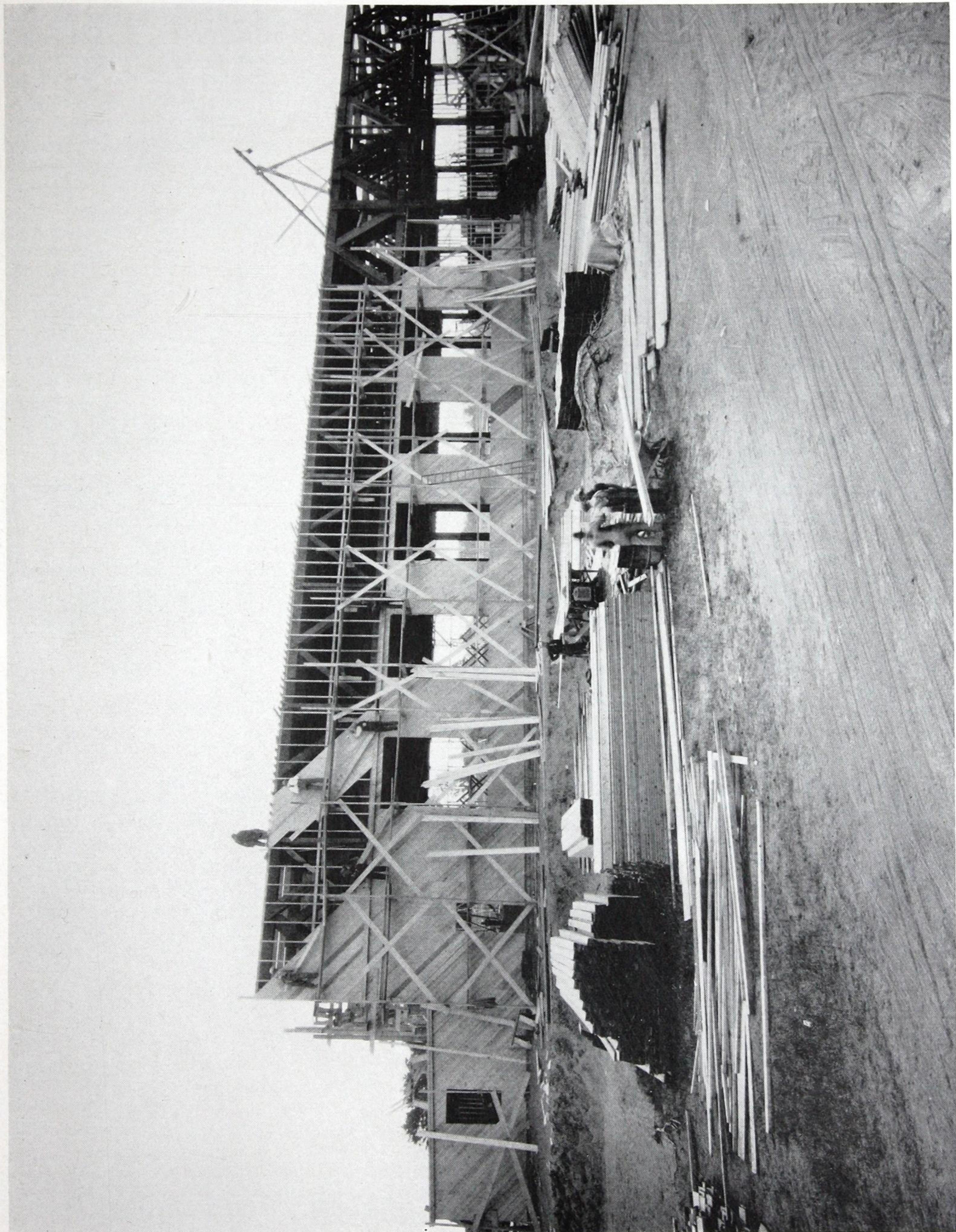
Commercial air transport is an infant industry; no one can foresee all of its requirements and possibilities. When the time comes that an airport must expand or change its site, or the location of some of the buildings, lumber again demonstrates the economy of its selection. Lumber hangars or other airport buildings are easily remodeled or enlarged to satisfy new developments, or, if necessary, they can be torn down quickly and cheaply and much of the material salvaged. A distinct advantage rests with the community which builds economical lumber hangars, sufficient for present requirements, with the assurance that when occasion demands the lumber hangar can be taken down, and much of the material re-used. If, on the other hand, a type of construction less easily altered has been used instead of lumber, the airport is committed definitely and permanently to the original layout. No matter how inadequate future developments may show it to be, the original plan must continue in use. The only alternative is to scrap expensive buildings when they are still comparatively new.

#### Fuel Economy

Walls and roofs should provide good insulation against low temperatures, in order to save fuel. Of the materials used principally for the exterior walls of hangars and similar buildings, wood is the highest in insulating value. It is not used in as great thicknesses, however, as masonry. The manner in which different materials are combined in the wall furthermore influences the heating economy of the building. Following are heat loss fig-



**Hangar at Municipal Airport, Olympia, Washington.** 80' clear span. Roof supported by bowstring roof trusses of the arch-rib type using TECO timber connectors.



Double landplane hangar being erected for Canadian Government in connection with Air Training Program. Sheathing placed diagonally on rear of hangar.

ures per hour per square foot of wall, per degree temperature difference between the inside and outside of the building for several customary wall types including those provided for in the plans:

1. Wood siding (matched or shiplapped) with 25/32" wood sheathing both under siding and on the inside face of studs.	0.20 heat units.
2. Wood siding (matched or shiplapped) with 25/32" wood sheathing on inside face of studs.	0.26 heat units.
3. Wood siding (matched or shiplapped) with building paper backing.	0.52 heat units.
4. Concrete block walls, 8" thick, no stucco.	0.56 heat units.
5. Solid concrete, 6" thick.	0.79 heat units.
6. Corrugated metal siding.	1.50 heat units.

The above figures are computed from figures published by the American Society of Heating and Ventilating Engineers, which are the most authoritative at present available. Heat loss figures also are available from publications of this Society for a large number of other combinations of building materials in walls and roofs, and with those above should be given consideration in selecting the type of construction particularly for large hangars.

In the larger type hangars a considerable economy in heating and increased fire resistance will be obtained by sheathing across the under side of the roof trusses with inch lumber or with metal lath and plaster used as a suspended ceiling. Fibre wall boards also are used for the purpose. These are more heat resistant per inch thickness than lumber, but are supplied usually only from 4/10 to 1/2 inch thick.

In the large hangars particularly it will be profitable to weather-strip windows and doors to prevent infiltration of cold air.

### Fire Safety of Timber

PERHAPS the most prominent facts in the minds of laymen concerned with the relative fire safety of timber and other construction materials are that wood burns and some of the others do not. The actual performance of timber and other structural materials exposed to fire is seldom considered further. A review of facts, however, resulting from fires in timber structures and structures of other materials indicates that other factors than that of combustibility are equally, if not more, important.

### Fire Hazards In Structures

In structures such as hangars, shops, garages, warehouses, etc., the fire hazard is not due to any appreciable

extent to the structural material itself, but to the contents or to external conditions to which the building is exposed. It is the nature of the contents which determines the rate of fire spread, once a fire is started. Where the contents are highly inflammable, fires generally spread through an entire building within a few minutes and temperature builds up rapidly. Where metal trusses are used, buildings are frequently rendered unsafe almost immediately because of the possible collapse of the unprotected metal.

Contrast this with structures built of timber. An outstanding example of the fire safety value of a lumber-built airplane hangar equipped with sprinklers was demonstrated at the U. S. Bureau of Standards. Seventeen fire tests consumed 40 army airplanes and hundreds of gallons of gasoline and oil. After the final fire test, in which four planes were placed in the hangar with tanks filled with 360 gallons of gasoline and 40 gallons of oil, and 15 gallons of gasoline spilled on the floor and ignited, the hangar was still in excellent condition, there being only two lightly charred places on the wood-sheathed walls and roof.

In a six-story warehouse fire at Tacoma, Washington, the fire raged for nearly four hours and in spite of the fact that fire broke out on three floors by following up an elevator shaft, no failures occurred either in the wood laminated floors or in the heavy timber supporting columns and stringers. In almost the entire building the original timbers were subsequently covered over and permitted to remain in use.

### Time to Failure

Based on standard fire temperatures of the American Society for Testing Materials tests of building materials, a temperature of 1100° F. is reached within six minutes. At this temperature certain structural metals have less than 1/2 of their normal tensile strength, and at 1700° F. they will not support the dead weight of a structure. Where there are highly combustible and volatile contents, such as oils, paints, lacquers, and certain processes, the fire may be a "flash" type and reach maximum temperatures of 2000-2500° F. in a few seconds, which will cause unprotected metal to collapse so quickly as to preclude the possibility of fighting the fire advantageously.

Wood will burn, but it loses its strength only in proportion to the degree of charring under fire temperatures. Penetration tests on wood exposed to standard fire temperatures show that in general wood chars and burns at the rate of about one inch in depth in 33 minutes. Based on the size of the members in the structures and a safety factor of 4 for the timbers, the actual failure time may be roughly computed for exposure to standard fire temperatures. For example, it is not unreasonable to expect that a tension member may have approximately three-fourths of its section charred before the stress in its remaining section is such that the timber might be ex-

pected to fail. Where timber joints are assembled with modern timber connectors, these may be expected to carry the load as long or longer than the chord members, due to the fact that the connectors are insulated from the heat and continue to carry most of their load even though the wood around the bolts may be charred by conducted heat. The higher the hazard or degree of combustibility of contents, the greater the relative fire safety of timber construction as compared to materials which may fail quickly under sudden and high temperatures.

### Salvage Value

A fire in a building with unprotected metal trusses usually results in a twisted mass, requiring considerable expense in clearing it away. In contrast, damaged timber trusses are often repairable in place, or are readily dismantled with common labor, and unburned timbers are salvageable.

Trusses of other materials than timber, when falling, almost invariably pull over the side walls, while wood trusses generally cause no such damage when the walls are of brick or masonry construction.

### Insurance Rates

While insurance rates may vary for different localities, heavy timber construction is generally recognized as having a much more favorable fire insurance rate than unprotected metal. Timber construction, sprinklered, is considered an exceptionally good fire risk and carries a proportionately low rate—in some instances it is the lowest obtainable.



Twisted wreckage resulting from fire in a metal structure.



Hangar nearing completion for Air Training Program by Canadian Government.

## Part II

## CONSTRUCTION PLANS

The following pages show construction plans of timber hangars. These designs were prepared by the Airport Section, Bureau of Federal Airways—Technical Development Division of the Civil Aeronautics Authority. All truss work employs the modern timber connector method of construction. These hangars have already been erected at several locations with economical results.

Planographed copies of these plans are available free of charge from the Timber Engineering Company, 1337 Connecticut Avenue, Washington, D. C.

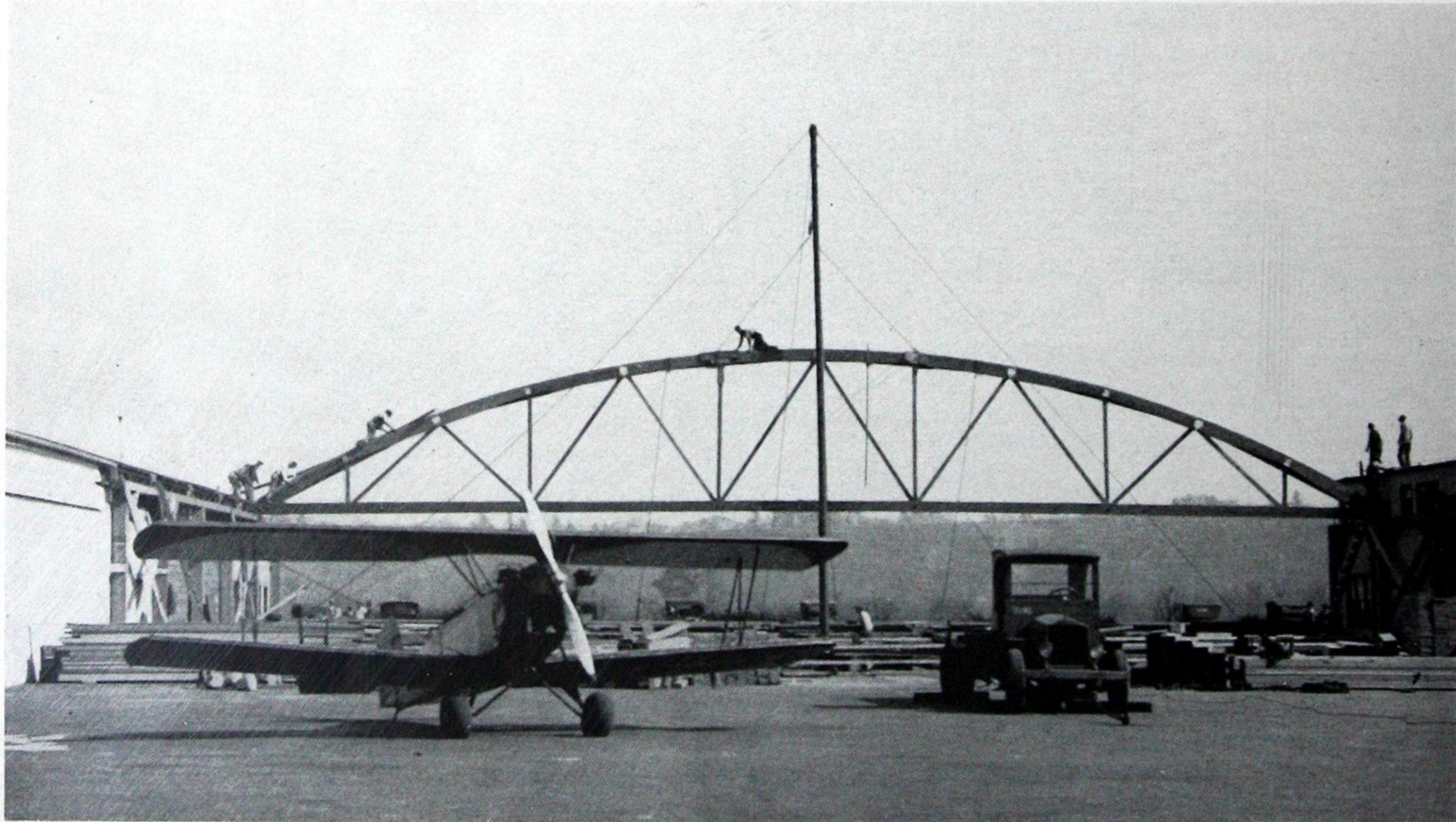
Wooden hangars may be economically constructed with door openings up to 200' in width. Truss designs for spans intermediate to those shown and for spans over 100' are available through the various commercial truss concerns. Most of these companies also are in a position to quote on the pre-fabricated parts of timber hangars.

**Multiple Unit Hangar for Small Airplanes**

(See plates 1 and 2)

This hangar was designed primarily for the provision of low-cost storage for small planes owned, usually, by private flying enthusiasts. Each space is in the shape of a 'T' and provides an individual garage and workshop for each plane. It also obviates the necessity of moving one or several planes to get the one desired out of the hangar. By the use of interior partitions which serve as walls for two hangars simultaneously the cost of storage is greatly lowered.

The hangar will receive planes of a 45' wingspread, an overall height up to 12', and an overall length of about 30'. The building is of all lumber construction. A concrete floor is shown which in a structure of this



Trusses in process of erection for hangar at Swan Island Airport, Portland, Oregon. Arch rib type of truss with a span of 120 feet. Note use of gin pole to erect completely fabricated and assembled unit.

type is not a complete necessity and may be eliminated in favor of a pair of strips to receive the wheels or a rolled cinder base. Small private airport owners will find hangars of this type, when built for rental, will produce funds which along with other income from gasoline, etc., will aid materially in defraying the cost of the airport operation.

#### 60' x 60' Hangar

(See plates 3 and 4)

This hangar is excellent for small airport use. It admits planes up to 60' wingspread, and 16' overall height. No floor has been shown in an effort to keep the cost at a minimum. It has been estimated that on the average this hangar may be constructed as shown for about \$2,000-\$2,500.

There are optional changes which may be effected as desired. It is not necessary to use the flat truss as shown although it is felt that this offers a very economical solution. If the builder desires a pitched truss or bowstring truss may be easily applied to the building as now detailed.

Shops and offices may be erected along the side and rear walls if desired. A door opening may also be had at the rear to allow entrance and exit of planes from either end. Doors, however, are usually the most ex-

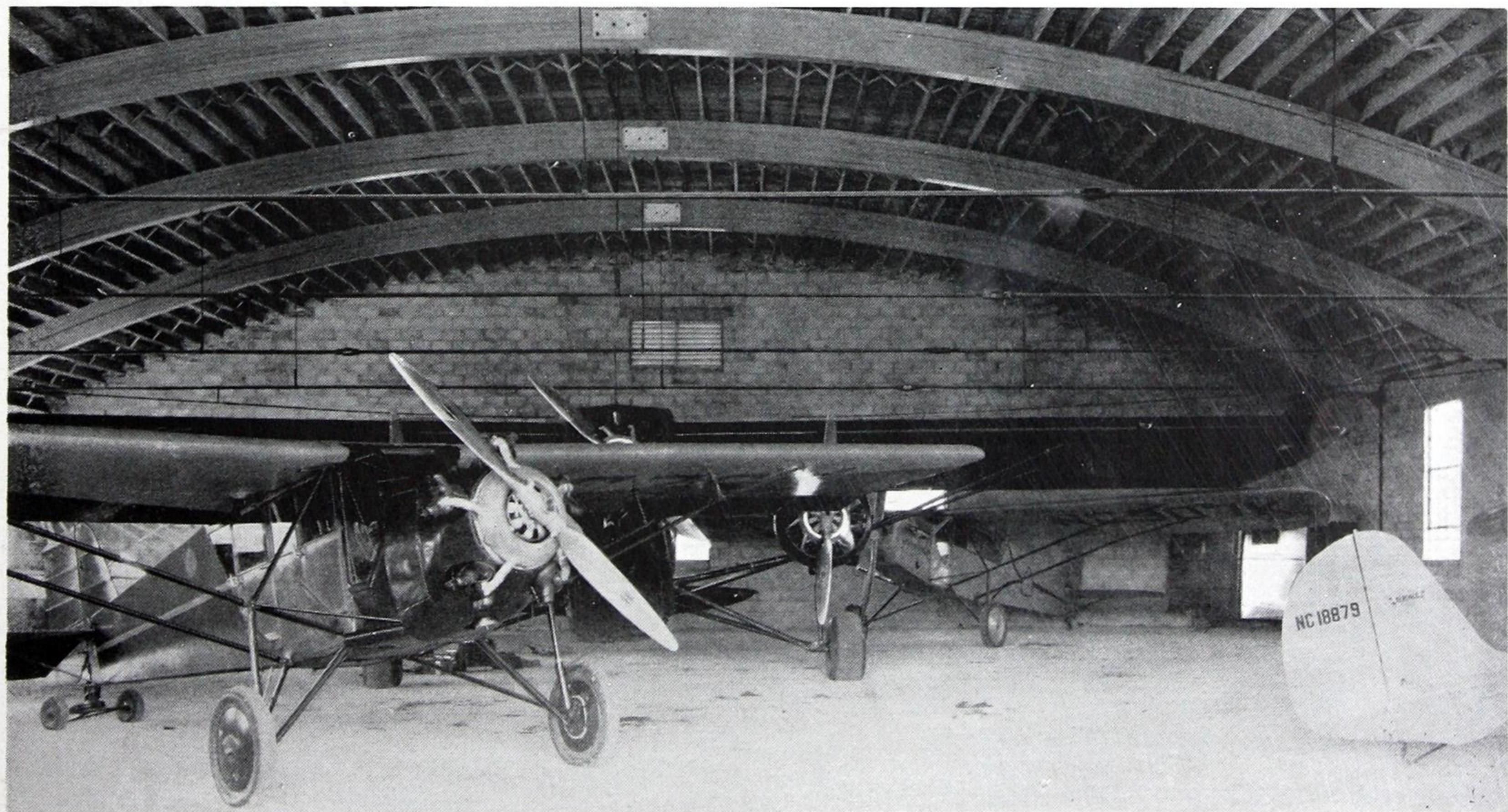
pensive item in a hangar and if low-cost is desired not more than one door is recommended.

#### 80' x 80' Hangar

(See plates 5 and 6)

This hangar begins to approach the size needed for the large planes used commercially. Planes up to 80' wingspread and a maximum height of 18' may be placed in this building. A floor of reinforced concrete is shown and while not absolutely necessary, it is probably advisable in view of the rather large weight of the planes which it may store. The probable cost of this hangar has been estimated at about \$6,000.

The timber trusses which are shown as glued-laminated bowstring trusses may be replaced by flat or pitched trusses. In most sections of the country the bowstring type either of the laminated type or the rib type will prove the most economical truss method. However, some builders may prefer the other types of trusses and they may be designed and built with relatively good economy. Inexperienced builders might find the bowstring type of truss a little difficult to build but once the methods are clearly understood the system offers no problems. Bowstring trusses may be secured in practically all sections of the country from commercial truss companies.



Glued-up laminated arches for an 80' x 100' municipal aeroplane hangar at Appleton, Wisconsin. Tie rods used to absorb horizontal thrust of arches.

A shop is shown along one side and one may be built on the other side if desired. An additional large door opening may be had at the rear if the additional expense is justified.

#### 100' x 100' Hangar

(See plates 7 and 8)

This hangar will take some of the large transport planes as well as some of the large military craft. The door opening has clearances of 100' horizontally and 22' vertically.

The comments on the 80' x 80' hangar apply equally to this building.

#### Other Types

Two other types of wood hangars not as widely used as the ordinary hangar using trusses are the laminated arch type and the Lamella type.

The laminated arches used to support the hangar roof consist usually of boards or laminations bent to the required curvature and glued together under pressure. The thickness of the lamination depends largely on the smallest radius of curvature of the arch. Ends of the boards should be beveled at their junction to obtain the most satisfactory results. Nailed laminated arches

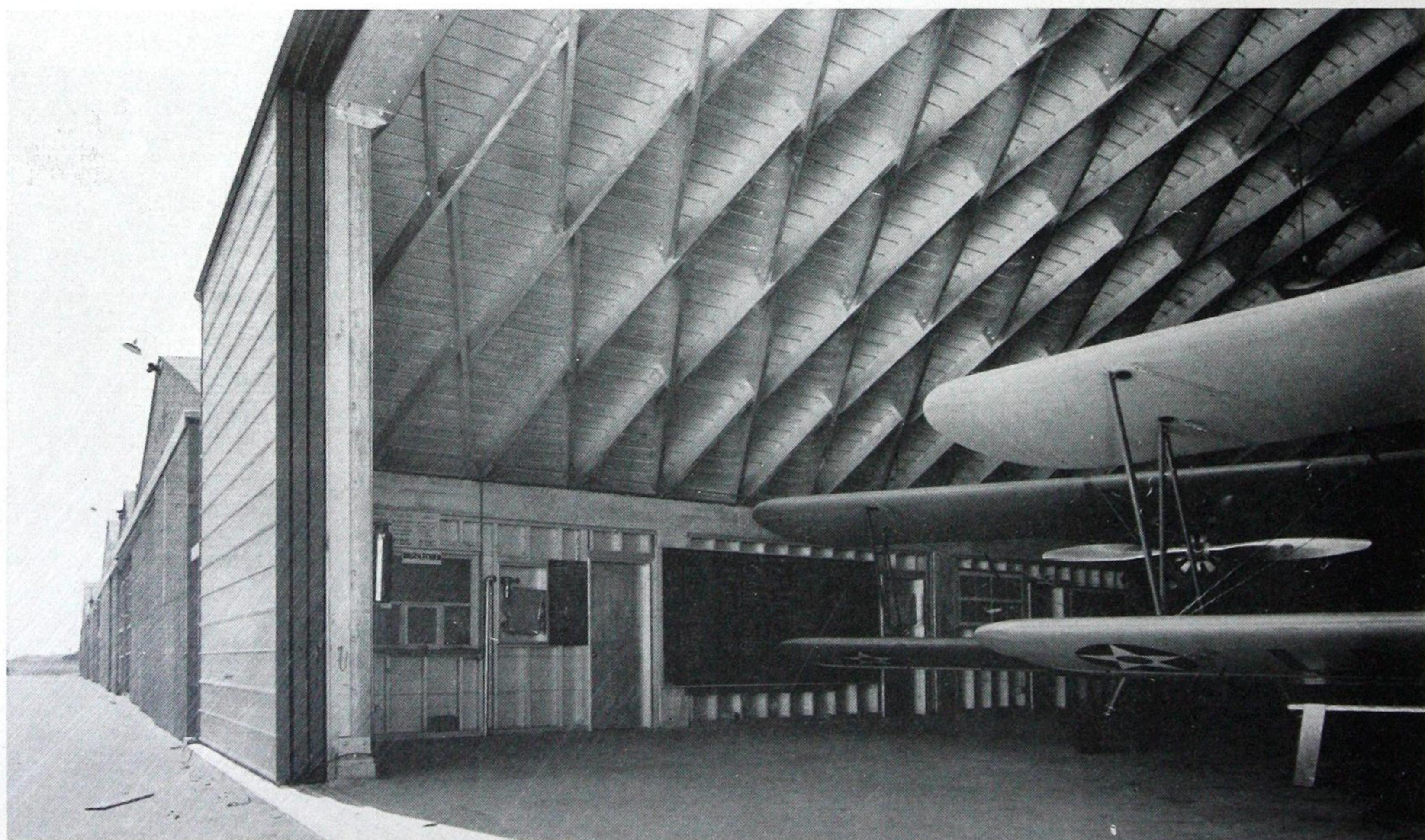
should not be included in the same category with the glued arch. The strength and rigidity of nailed arches does not compare with glued work even when accurately and carefully done for test purposes. For information on this type of arch see "The Glued Laminated Wooden Arch" by T. R. C. Wilson. (Technical Bulletin No. 691—U. S. Department of Agriculture.)

A well fitted shop and experienced labor is required to properly fabricate a glued arch. If this system is to be employed, arches should be purchased directly from a reputable firm experienced in this work.

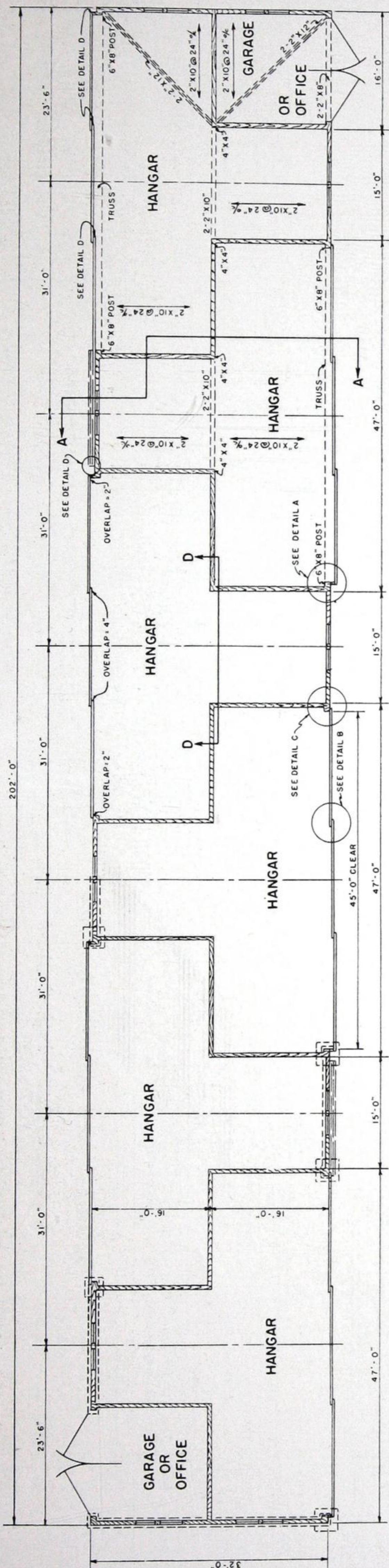
The other type, or the Lamella roof system, consists of the weaving together of curved specially-cut pieces or lamellas into a woven-like arch. A picture of this type is shown below. This system of roof construction is patented and hence can only be built by the truss companies having rights to these patents.

#### Other Sizes

Clear spans from 30' to 160' may be soundly and economically accomplished with wood trusses. For information write the Timber Engineering Company, 1337 Connecticut Avenue, Washington, D. C., or the various truss manufacturers.



Lamella type roof framing used on a large Army hangar in California. Woven web is the lamella system.

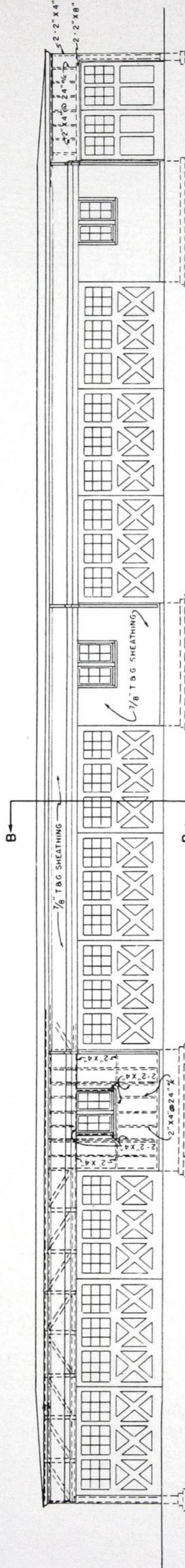


*Dotted Lines Indicate Foundation.*

PLAN

*Dotted Lines Indicate Root Framing.*

10 20 30 40 50



## SIDE ELEVATION

## BILL OF MATERIALS

MISCELLANEOUS					
ITEM	SIZE	AMOUNT	TYPE		
ROOFING	65 ROLLS	6500 SQ FT	PER ROLL	MINERAL SURFACED	
PAINT	55 GAL				
NAILS	3 KEGS		ROOFING		
"	8 d	2 KEGS			
"	10 d	3 KEGS			
"	16 d	1 KEG			
"	20 d	3 KEGS			
WINDOWS					
ITEM	SIZE	NO.	SIZE		
SINGLE SASH WINDOWS	20	30" X 64" X 1 3/4"	COMPLETE		
FRAMES	20	1 1/4" THICK	COMPLETE		
WINDOW LOCKS	20				

**CIVIL AERONAUTICS AUTHORITY**  
BUREAU OF FEDERAL AIRWAYS — TECHNICAL DEVELOPMENT DIVISION

## MULTIPLE UNIT HANGAR EOB SMALL AIRPLANES

REV. APPROVED:	C. W. Muller, SECTION CHIEF		
REVIEWED:	Charles B. Donaldson SR. ENGINEER		
SUBMITTED:	A. H. Wessel		
CHECKED:	E. G. B.		
DRAWN BY:	D. E. Clinton		
DATE:	A-20-40	Sheet 1	No. 170

END ELEVATION

SCALE:  $\frac{1}{8}$ " = 1'

SCALE :  $\frac{1}{4}$  = 1'

BILL OF MATERIAL					
CONCRETE		FOUNDATION BOLTS		GARAGE	
ITEM	QUANTITY	ITEM	NO.	SIZE	ITEM
FOUNDATION	4.5 CU. YDS	ANCHOR BOLTS	59	3/4" X 8"	COMPLETE DOORS
BEARINGS	"	WASHERS	59	3/4"	UPPER PANELS D.S.A.C.
FLOOR	123.5 "				DOOR LATCHES & LOCKS
TOTAL	128 CU.YDS.				STRAP HINGES
HANGAR DOOR TRACKS - 2 SETS					
ITEM	NO.	SIZE	TOTAL	LENGTH	TYPE
RAILS (INSIDE DOORS)	6	12"	33'	1"	INDUSTRIAL
RAILS (MIDDLE DOORS)	6	12"	47'	5 1/2"	"
RAILS (OUTSIDE DOORS)	2	12"	186	2"	"
RAIL ANCHORS	48	3" - 4 1/4"	11 1/2"	"	CHANNELS
	18	"	7 3/8"	"	"
	18	"	5"	"	"
RAIL CLIPS	198	1 1/16" X 1 1/2" X 1/2"			
RAIL CLIP BOLTS & NUTS	198	3/8" X 1 1/2"			MACHINE
WASHERS	396	5/8"			ROUND
DRAINAGE					
ITEM	AMOUNT	SIZE	SIZE	MATERIAL	SHAPE
GUTTER	468 LINEAL FT.	6"-24 GA.	6"-24 GA.	GALVANIZED IRON	
DOWNSPOUTS	6	4"-24 GA.	4"-24 GA.	CORRUGATED GAL. IRON	ROUND
TRAPS	6				
DRAINAGE PIPES	AS REQUIRED				

PLATE 1

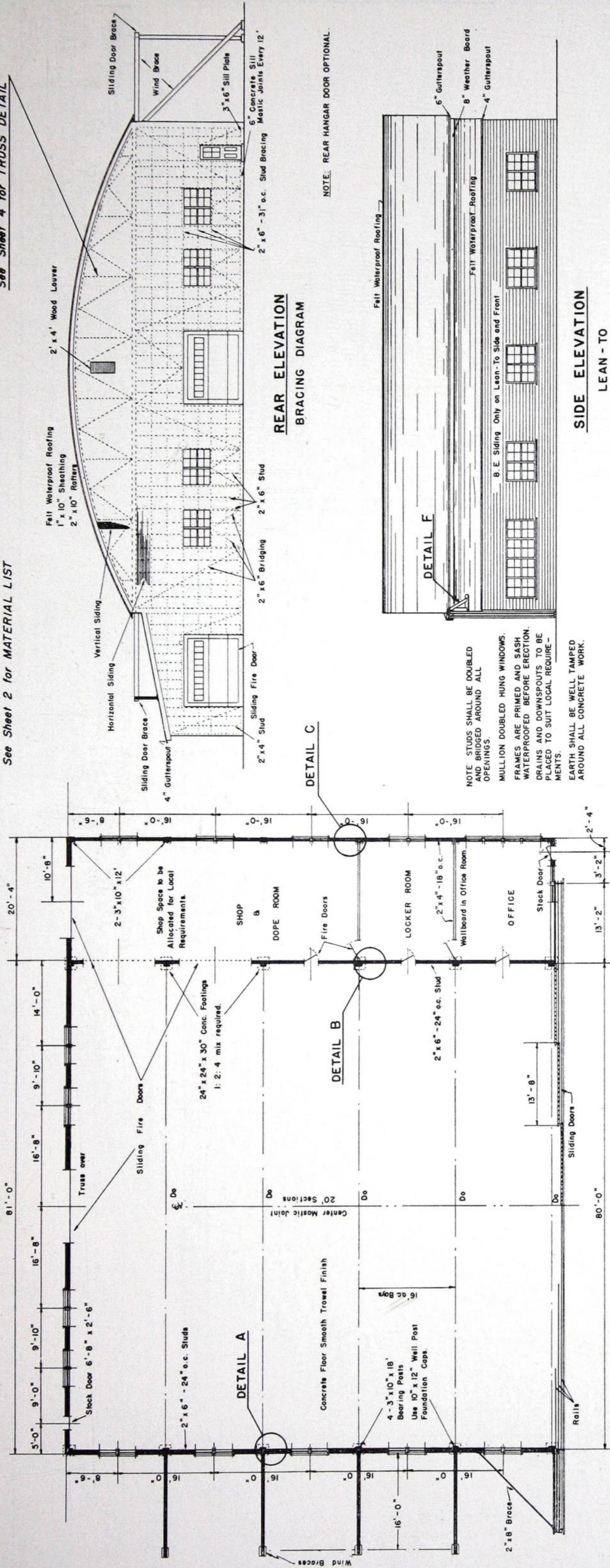






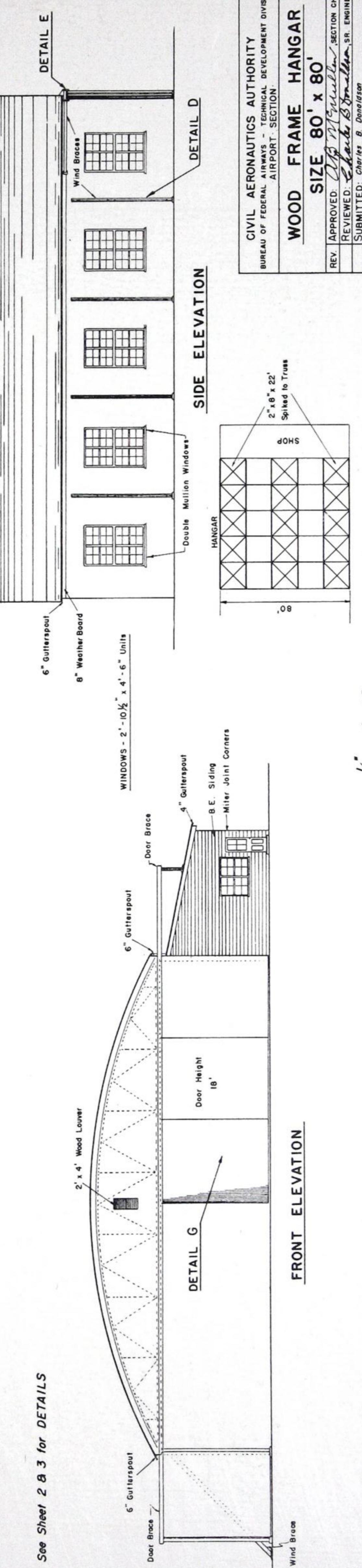
See Sheet 2 for MATERIAL LIST

See Sheet 4 for TRUSS DETAIL



PLAN

See Sheet 2 & 3 for DETAILS



SCALE:  $1/8" = 1' - 0"$

BAY BRACING DIAGRAM

REV. APPROVED: *John M. Gosselin*, SECTION CHIEF

REVIEWED: *Frank B. Donelson*, SR. ENGINEER

SUBMITTED: *Charles B. Donelson*

DRAWN BY: *H. P. Gosselin, Jr.*, ARCH.

DATE: 7-18-40

SHEET - One

DR. No. 179

PLATE 5

CIVIL AERONAUTICS AUTHORITY

BUREAU OF FEDERAL AIRWAYS - TECHNICAL DEVELOPMENT DIVISION

AIRPORT - SECTION

WOOD FRAME HANGAR

SIZE 80' x 80'

REV. APPROVED: *John M. Gosselin*, SECTION CHIEF

REVIEWED: *Frank B. Donelson*, SR. ENGINEER

SUBMITTED: *Charles B. Donelson*

DRAWN BY: *H. P. Gosselin, Jr.*, ARCH.

DATE: 7-18-40

SHEET - One

DR. No. 179

MATERIALS LIST PER TRUSS						
Lumber (545)				Hardware		
Mem#	Size	Length	Make Cut From	Order	Item	Size
Top Chord	2" x 4"	10' 50'	Random	700	208	Split Rings
Bottom Chord	4" x 8"	19'-6"	4 20'-0"	4 214	20	Mall. Iron Sh. Pl.
Brace	4" x 8"	20'-0"	4 20'-0"	4 214	34	Machin. Bolts
Splice Plates	4" x 8"	6'-8"	9 20'-0"	3 160	44	"
End Filler	4" x 8"	4'-9"	2 10'-0"	1 27	30	"
V1	4" x 4"	3'-4"	2 14'-0"	2 38	10	"
V2	4" x 4"	6'-10"	2 14'-0"	1 19	216	Plate Washers
V3	4" x 4"	9'-2"	2 See V1	2	Steel Straps	3/8" x 9" x 10' 5"
V4	4" x 4"	10'-3	2 20'-0"	2 54	Give & No/te as required	
D1	4" x 4"	7'-0"	2 14'-0"	1 19		
D2	4" x 4"	7'-0"	2 14'-0"	1 19		
D3	4" x 4"	9'-5"	2 See V4			
D4	4" x 4"	9'-5"	2 20'-0"	1 27		
D5	4" x 4"	11'-0"	2 12'-0"	2 32		
D6	4" x 4"	11'-0"	2 12'-0"	2 32		
D7	4" x 4"	11'-5"	2 12'-0"	2 32		
					Total	1587

SPECIFICATIONS
<b>LUMBER</b> Lumber shall be of a structural grade with minimum allowable working stresses in lbs. per sq in. as follows: 880# Compression parallel to grain 1200# Extreme fiber in bending 1,000,000# Modulus of elasticity
<b>TIMBER CONNECTORS</b> Split ring connectors shall be made of mild steel, $2\frac{1}{2}$ " inside diameter, $\frac{3}{4}$ " in depth, $.163"$ thickness of center beveling to $.143"$ at edges, and having a load capacity, with a $\frac{1}{2}$ " bolt, of 2850# parallel to grain. Shear plate connectors shall be made of malleable iron, 4" in diameter, $.20"$ thickness of plate, $.62"$ depth of flange, $.81"$ diameter of bolt hole, and having a load capacity, with a $\frac{3}{4}$ " bolt, of 5080# parallel to grain.

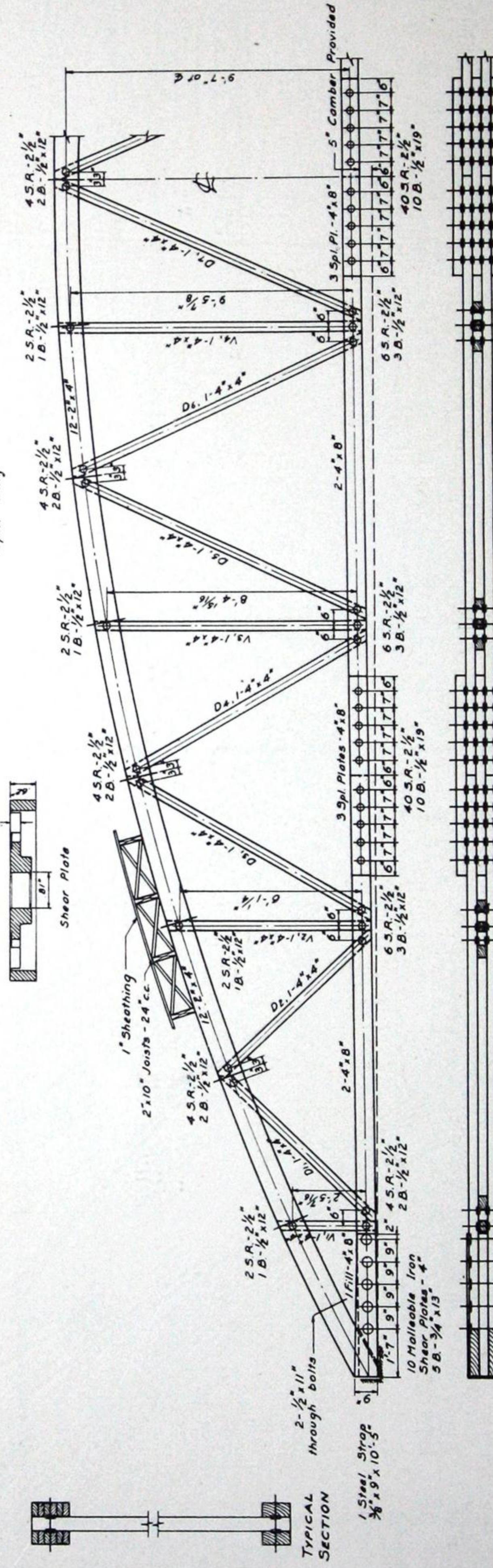
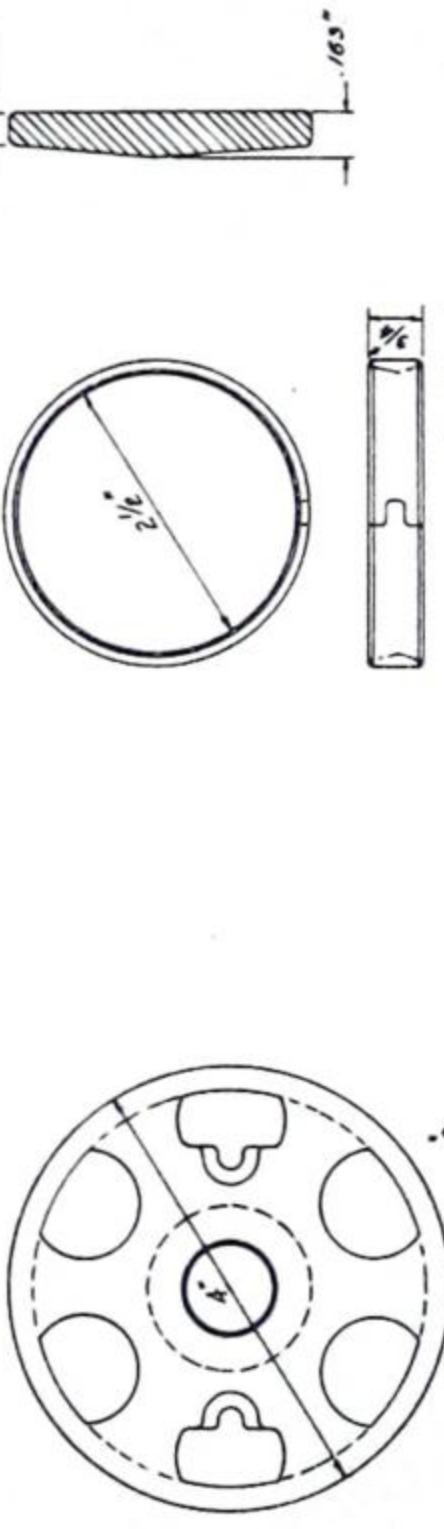
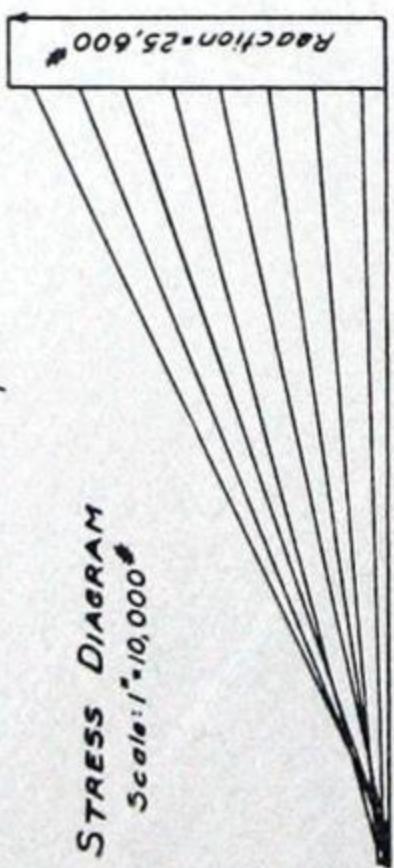
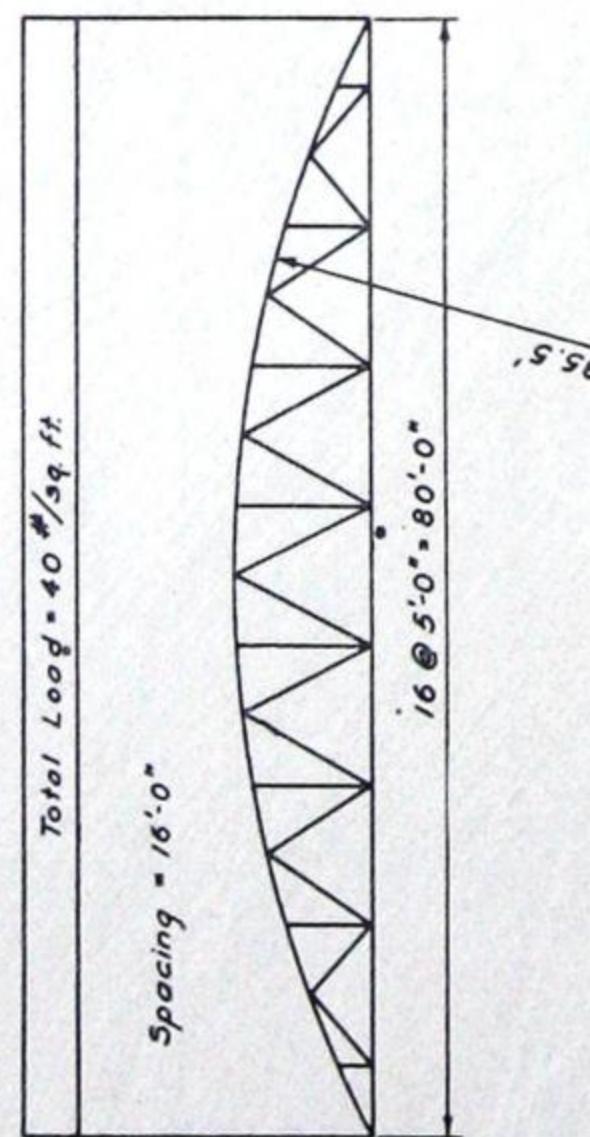
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*NOTES*

Top chord members are built up to the desired curvature with 2" x 4" lumber, glued with casein glue and nailed from both sides with 60 d spikes spaced 12" o.c. and in a staggered position about 1" from the edge. This nailing will assist in holding the members in position while the glue is setting up. Laminations are further reinforced at the panel points by a  $\frac{1}{2}$ " through bolt.

In fabrication and assembly, lay out truss as shown. Cut web members off to fit truss; then bore all holes for bolts. Disassemble truss and cut connector grooves. Reassemble truss with connectors in place. Finally lift into place with a gin pole or crane.

Trusses must be properly braced laterally with "X" braces attached to the verticals 20' o.c.



WOOD BOWSTRING HANGAR ROOF TRUSS  
SPAN - 80'-0" RISE - 10'-0" SPACING - 16'0"

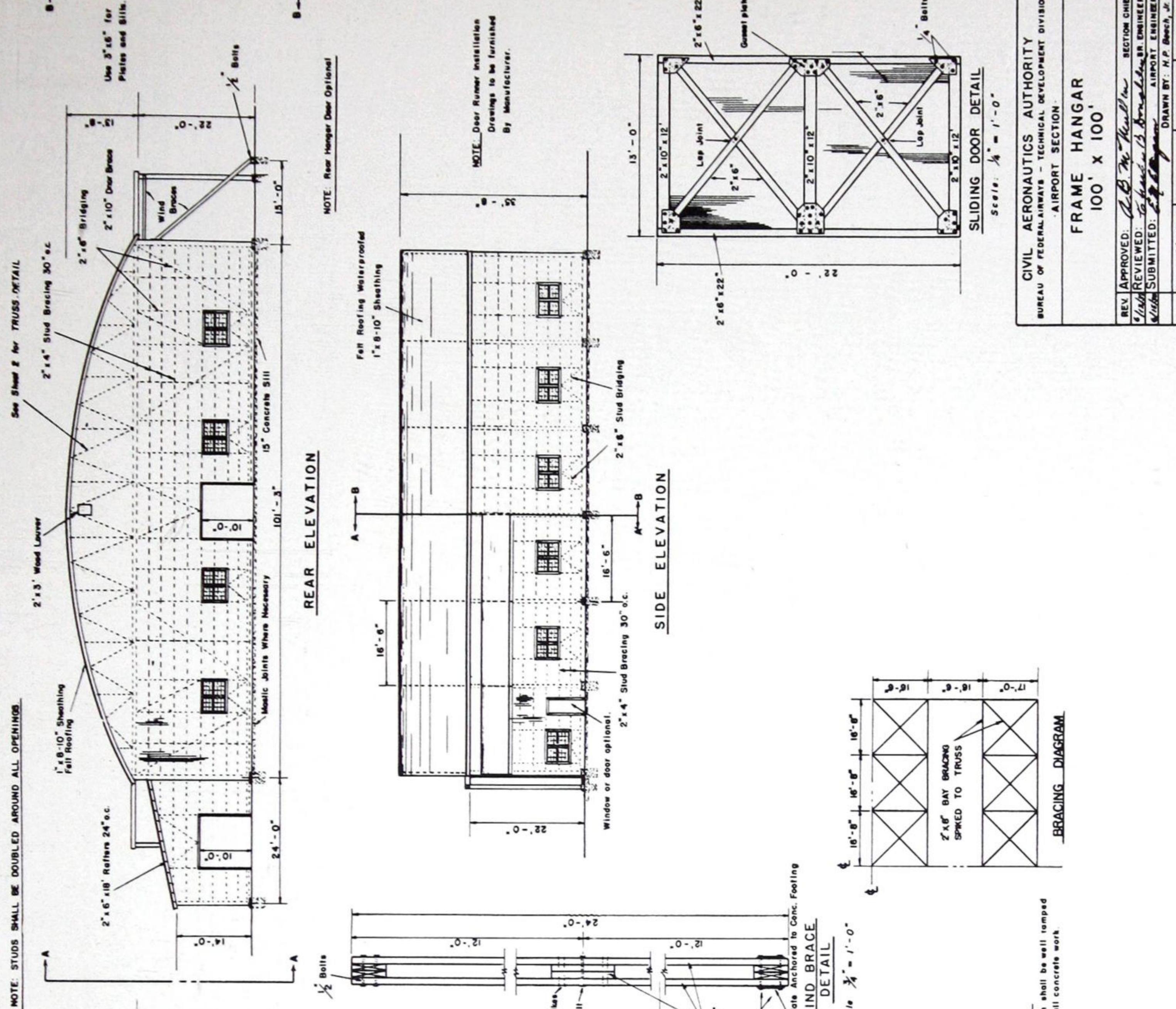
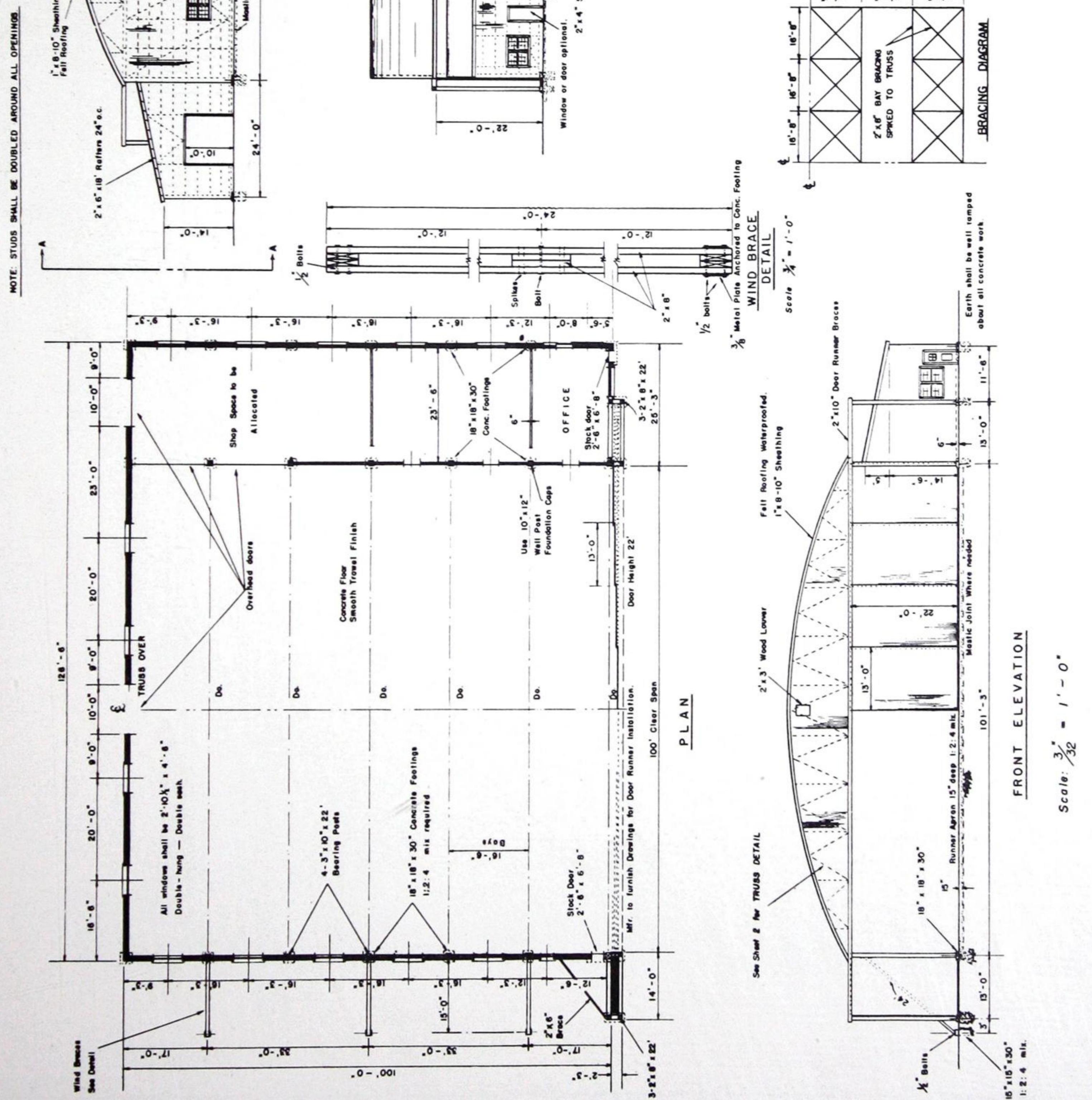
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**CIVIL AERONAUTICS AUTHORITY**  
BUREAU OF FEDERAL AIRWAYS—TECHNICAL DEVELOPMENT DIVISION  
AIRPORT SECTION

**WOOD FRAME HANGAR**  
**SIZE 80' - 80'**

CIVIL AERONAUTICS AUTHORITY  
BUREAU OF FEDERAL AIRWAYS—TECHNICAL DEVELOPMENT DIVISION  
AIRPORT SECTION

WOOD FRAME HANGAR  
SIZE 80' x 80'



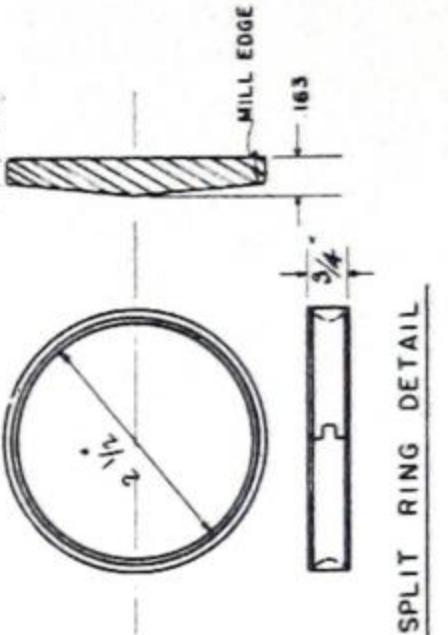
Lumber Cutting Bill							
Material	Size	Length	Mark	Cut	H. D.	Mark	Size
2" x 6"	1700'	10'	0	0	0	0	74"
4" x 10"	2040'	10'	0	0	0	0	74"
5" x 10"	940'	2'	0	0	0	0	74"
6" x 10"	470'	12'	4	160	0	0	74"
7" x 10"	470'	12'	4	160	0	0	74"
V1	4" x 4" x 3"	3'-5"	2	500	0	0	4" x 4" x 3"
V2	4" x 4"	70'	2	14"	1	19	4" x 4"
V3	4" x 4"	1040'	2	10"	2	27	4" x 4"
V4	4" x 4"	1240'	2	12"	2	32	4" x 4"
V5	4" x 4"	1240'	2	16"	2	38	4" x 4"
Total Lumber - 2386							
Hardware							
No	Item	Size	No	Item	No	Item	Size
304	Split Rings	2 1/2" x 1/8"	42	Machine Bolts	15	Machine Bolts	15 x 1/4"
50	Machine Bolts	1/2" x 1/2"	2	Steel Shoes	45	Steel Shoes	45 x 1/4"
40	"	"	292	Cathoderesler & Co			
10	"	"	1 1/4" x 1/8"				Cathoderesler & Co

## *SPECIFICATIONS*

**LUMBER**—Lumber shall be of a structural grade with minimum allowable working stresses in lbs. per sq. in. as follows:

880# Compression parallel to grain  
1,200# Extreme fiber in bending.  
1,600,000# Modulus of elasticity.

**TIMBER CONNECTORS**—Split ring connectors shall be made of mild steel,  $2\frac{1}{2}$ " inside diameter,  $9\frac{1}{4}$ " in depth,  $.159$ " in thickness, and having a load capacity, with a  $\frac{1}{2}$ " diameter bolt, of 2800# parallel to grain.



## NOTES

Top chord members are built up to the desired curvature with 2 $\frac{1}{4}$ " #10" number, glued with casein glue, and nailed, at the same time with 2 00 spikes, spaced 12" o.c. and in a staggered position, about 1" from each edge. This nailing will assist in holding members in position while the glue is setting up. Laminations are further reinforced at panel points by a through bolt,  $\frac{1}{2}$ " in diameter.

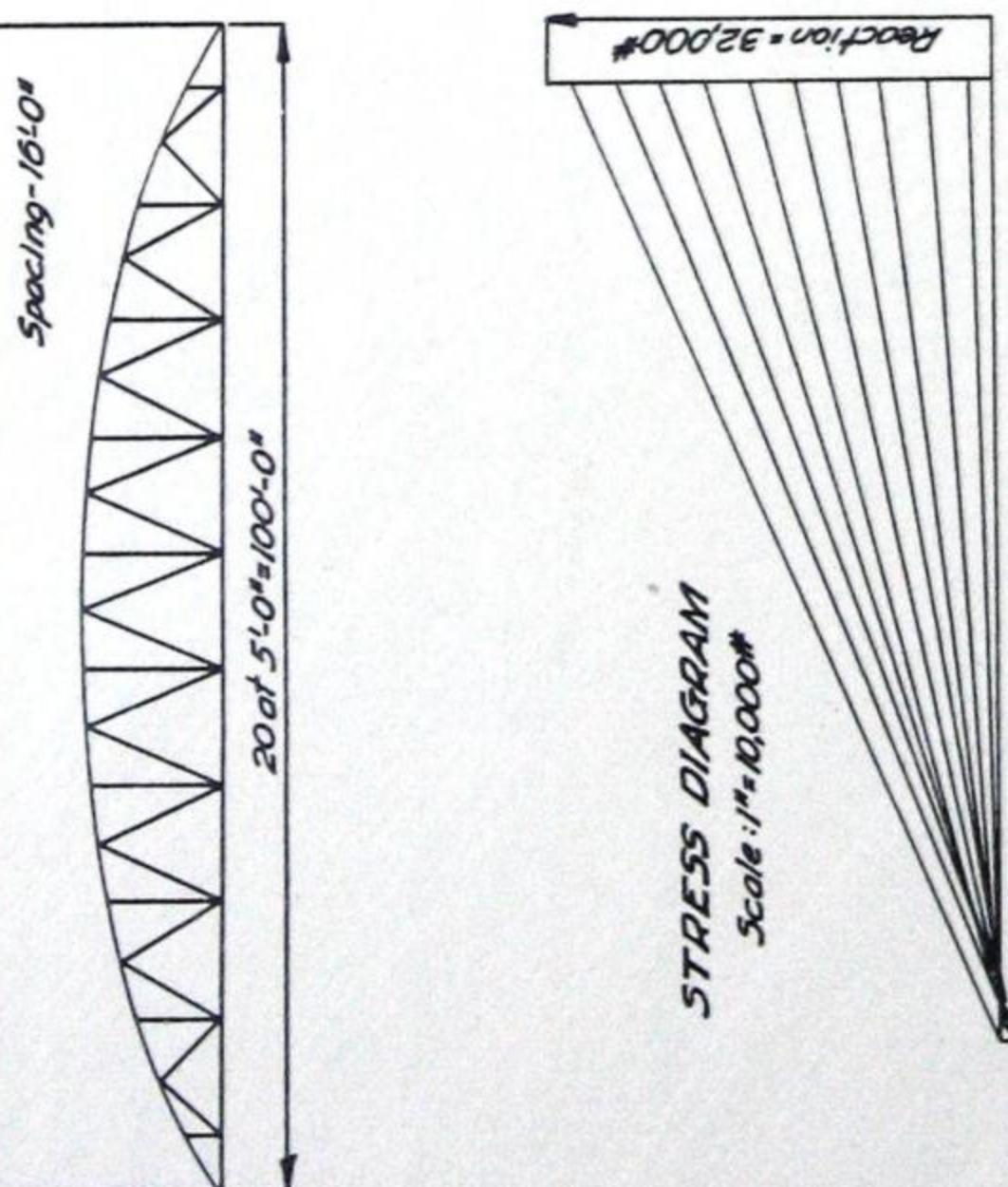
In fabrication and assembly, lay out truss as shown. Cut web members off to fit trusses when horizontal hole for bolts

*Disassemble truss and cut connector grooves. Reassemble truss with connectors in place. Finally lift into place with a gin pole or crane.*

*Trusses must be properly broiced against each other with "X" broces attached to verticals 25' o.c.*

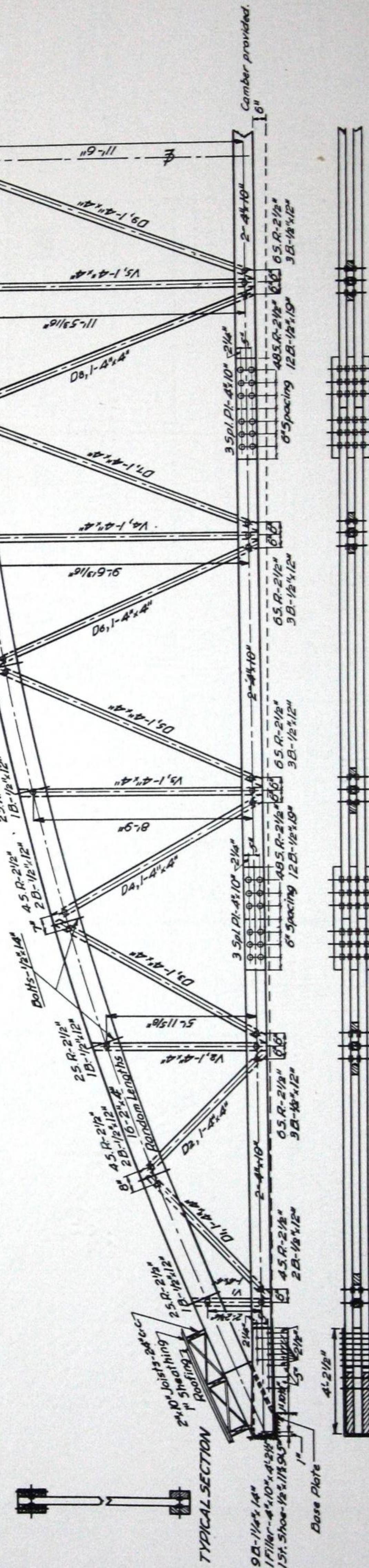
*This truss as shown has a parabolically shaped top chord. If a circular segment is desired, the only changes necessary will be an influential change in the stress diagram, a change of the lumber list and of the vertical dimensions.*

Dead Load + Live Load = 40#/sq ft.



### STRESS DIAGRAM

Scale: 1" = 10,000'



WOO BOWNDING HANGAO 0005 TD1155

SCANT, NOCK, DISC = 1210" SPACED/1000', 1/1000"

Scale:  $1/2'' = 1\text{ft}$

Scale in feet

*(Bawstring trusses of this type and system of construction are readily applicable to spans from 60'-180')*

**CIVIL AERONAUTICS AUTHORITY**  
BUREAU OF FEDERAL AIRWAYS - TECHNICAL DEVELOPMENT DIVISION  
AIRPORT SECTION

ESTATE PLANNING TOOLS: DETAILS

IGAR - 1 R

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13.6.8

40

SHEET 2



Use of traveling cranes to erect 112 ft. double Warren spans. Canadian Air Training Program hangar.

## WHERE ADDITIONAL LUMBER INFORMATION MAY BE OBTAINED

THIS publication is a part of the service to distributors and consumers of lumber sponsored by the National Lumber Manufacturers Association. It is suggested that those desiring additional information regarding the respective species of wood write the following regional associations:

American Walnut Manufacturers Association.....	Chicago, Ill.
American Walnut.	
Appalachian Hardwood Manufacturers, Inc.....	Cincinnati, O.
Appalachian Ash, Basswood, Beech, Birch, Butternut, Chestnut, Cherry, Elm, Hickory, Maple, Yellow Poplar, Red Oak, White Oak, Walnut.	
California Redwood Association.....	San Francisco, Cal.
California Redwood.	
Hardwood Dimension Manufacturers Association.....	Louisville, Ky.
American Walnut, Ash, Basswood, Beech, Birch, Butternut, Chestnut, Cherry, Elm, Hickory, Maple, Yellow Poplar, Red Oak, White Oak, Hemlock, Tamarack, White Pine, Cypress (yellow), Cottonwood, Gum (black), Gum (red and sap), Hackberry, Magnolia, Pecan, Persimmon, Sycamore, Tupelo, Willow.	
Mahogany Association, Inc.....	Chicago, Ill.
Mahogany.	
Maple Flooring Manufacturers Association.....	Chicago, Ill.
Maple, Beech and Birch Flooring.	
Northeastern Lumber Manufacturers Association.....	New York, N. Y.
Northern White Pine, Norway Pine, Eastern Spruce, Balsam Fir, Northern Hardwoods.	
Northern Hemlock and Hardwood Manufacturers Association.....	Oshkosh, Wis.
Hemlock, Birch, Maple, Basswood, Elm, Ash, Beech, Tamarack, White Pine.	
Northern Pine Manufacturers Association.....	Minneapolis, Minn.
Northern White Pine, Norway Pine, Eastern Spruce, Tamarack.	
Southern Cypress Manufacturers Association.....	Jacksonville, Fla.
Tidewater Red Cypress.	
Southern Hardwood Producers, Inc.....	Memphis, Tenn.
Ash, Basswood, Beech, Cypress (yellow), Cottonwood, Elm, Gum (black), Gum (red and sap), Hackberry, Hickory, Maple (soft), Magnolia, Oak (white), Oak (red), Poplar, Pecan, Persimmon, Sycamore, Tupelo, Willow.	
Southern Pine Association.....	New Orleans, La.
Longleaf and Shortleaf Southern Pine.	
West Coast Lumbermen's Association.....	Seattle, Wash.
Douglas Fir, West Coast Hemlock, Sitka Spruce, Western Red Cedar, Port Orford Cedar.	
Western Pine Association.....	Portland, Ore.
Ponderosa Pine, Idaho White Pine, Sugar Pine, Larch, Douglas Fir, White Fir, Engelmann Spruce, Red Cedar, Incense Cedar.	
The Veneer Association.....	Chicago, Ill.

## NATIONAL LUMBER MANUFACTURERS ASSOCIATION

1337 Connecticut Ave., Washington, D. C.

### FIELD OFFICES

Chicago

New York

New Orleans

San Francisco

### COOPERATING ORGANIZATIONS

Douglas Fir Plywood Association.....	Tacoma, Wash.
National Hardwood Lumber Association.....	Chicago, Ill.
National-American Wholesale Lumber Association.....	New York, N. Y.
National Retail Lumber Dealers Association.....	Washington, D. C.
National Association of Commission Lumber Salesmen.....	Cleveland, O.
National Door Manufacturers Association.....	Chicago, Ill.
National Association of Hardwood Wholesalers.....	Chicago, Ill.
National Wholesale Lumber Distributing Yard Association.....	Baltimore, Md.
Red Cedar Shingle Bureau.....	Seattle, Wash.